RICHARD THORNTON FISHER

1876-1934

DIRECTOR OF THE HARVARD FOREST
FOR ITS FIRST TWENTY-SEVEN YEARS

Selections from his publications
with a memorial biography by Henry James

Compiled by Richard Huntington Forbes
Christmas 1985

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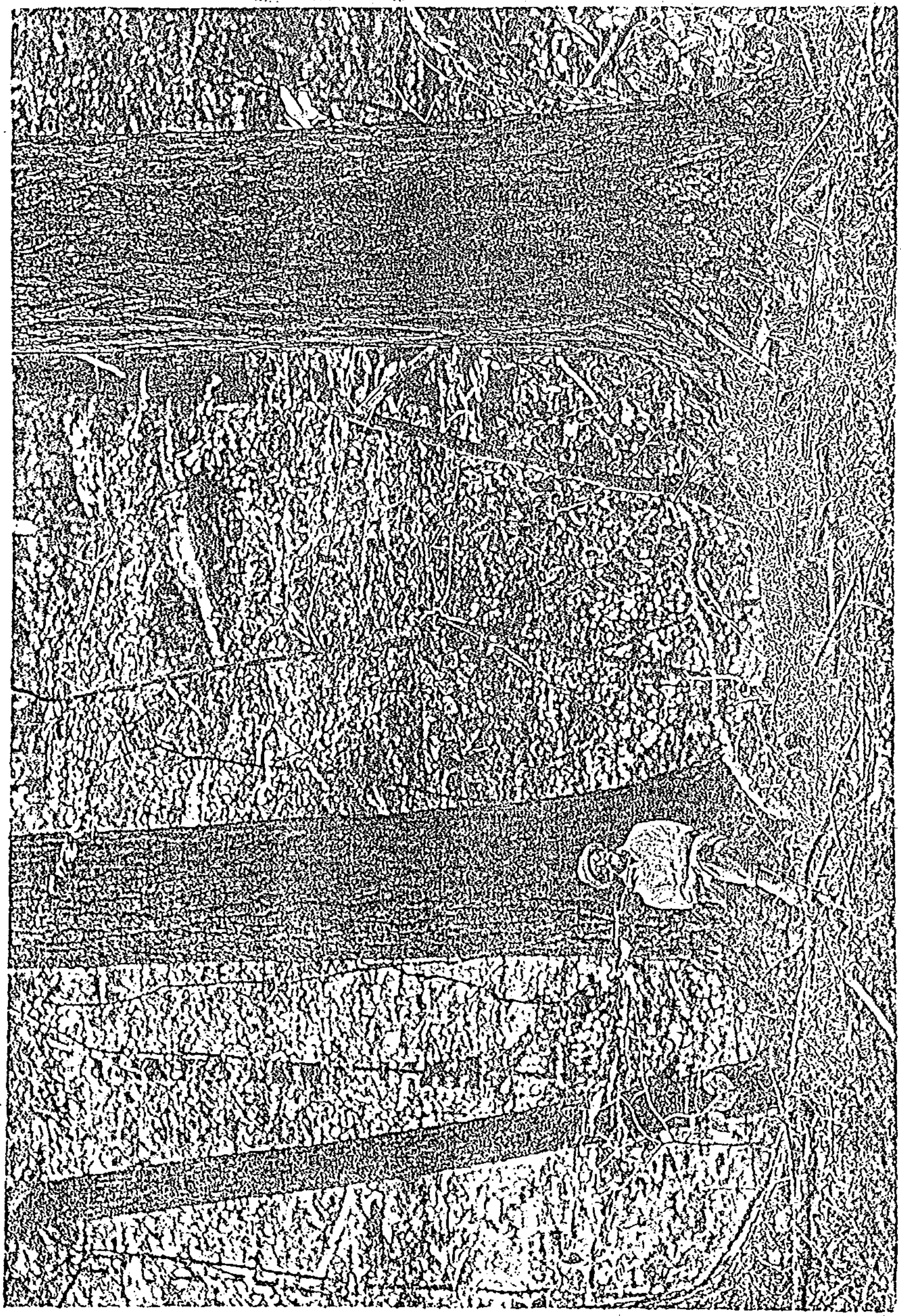
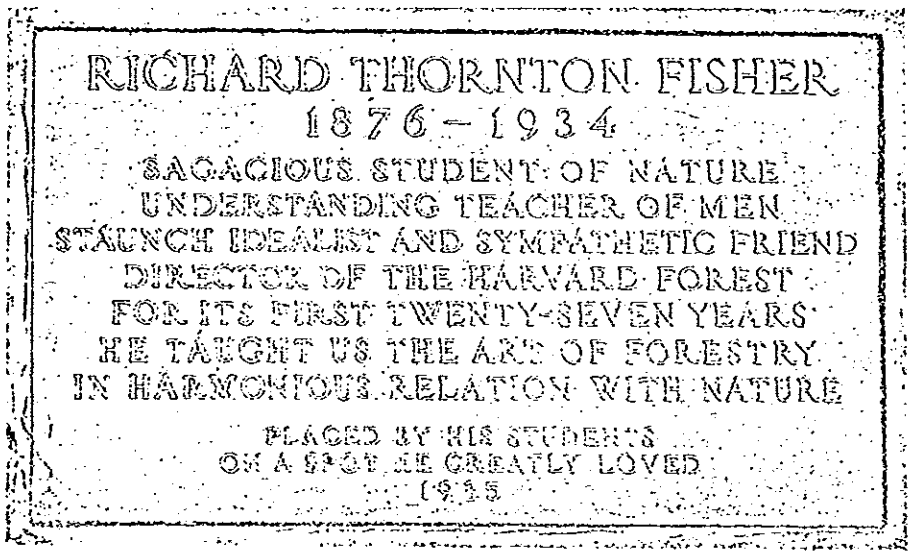
*These selections have been chosen for their general interest. Readers wishing to examine Professor Fisher's more technical publications may obtain these from the institutions noted in the Bibliography or may write directly to the compiler at Post Office Box 56, Chelsea, VT 05038.





THE FISHER MEMORIAL TABLET

Also illustrated, most strikingly and convincingly, is the soundness of the basic philosophy of working in harmony with nature, so ably developed and championed by Richard Thornton Fisher, first director of the Harvard Forest (1907-1934), in laying down an ecological foundation as the only secure base on which to erect a structure of silviculture which will stand the tests of time and economic practicability. Almost without exception, the success or failure of the treatments carried out may be directly measured against the extent to which they departed from this basic philosophy.

John C. Goodlett, "The Development of Site Concepts at the Harvard Forest and their Impact upon Management Policy," Harvard Forest Bulletin No. 47, 1960, p. 27.

RICHARD THORNTON FISHER

ANY history of Harvard's work in forestry, written now or hereafter, will begin by naming Richard T. Fisher, whose untimely death occurred on the ninth of June, 1934. When the University undertook to teach forestry in 1903 he was selected by President Eliot to organize the course and was appointed Instructor. Soon after, when the Harvard Forest at Petersham was acquired in 1907, he became in fact what he was later to be in name, its director. With respect to all Harvard's doings in the field of forestry during the years that have rolled by since then, his has been the guiding mind, so that what has been accomplished has been largely his achievement. In retrospect it all seems to be tinged by the colors of his personality. Fisher and his work can no longer be thought of separately.

Richard Thornton Fisher, born in Brooklyn, New York, November 9, 1876, was the only son of Edward Thornton Fisher who had been the top boy in his form at Exeter and class poet of the Harvard Class of 1856. Bad health interfered with the elder Fisher's career, but during most of his life he engaged in teaching; first in Brooklyn and later in Lanesboro, Berkshire County, where from 1883 to 1912 he conducted the Home and Preparatory School for boys. He was a gentle soul and a man of native refinement of taste and intellect, just as was his son. His wife, Richard's mother, was Ellen Bowditch Thayer, a sister of Abbott H. Thayer, the painter.

Abbott Thayer, in whose company young Fisher spent a good part of many boyhood vacations at Dublin, New Hampshire, was an important influence in the nephew's development. He was, as some people know but many do not, a remarkable naturalist as well as a distinguished painter. His theories about concealing coloration went far beyond Wallace's, were truly original and have now, in the main,

been accepted.* He not only saw birds and all other living things with a painter's highly trained eye, but he made what I think it is correct to call a truly scientific approach to the study of the relation of their shadow patterns and color patterns to concealment and therefore to their environment and their habits. Any scientist knows that it is hard to recognize what is before your eye if it is not supposed to be there, and that a large proportion of the "discoveries" have been made because this person or that had confidence enough in his own perceptions to recognize what countless other people might have noticed long before. Thayer could see that the colors in which a "conspicuous" bluejay is dressed are no brighter than the colors of a snowy landscape; that a scarlet tanager, who seems to demand attention if he pauses for a moment at the edge of the lawn, becomes almost invisible in the top of the tree in which he feeds or nests. And he knew, or thought he discovered, the whys of such things. In his company Fisher learned what was ultimately more valuable to him than would have been an orthodox education in systematic ornithology or botany. He acquired, along with a great love of nature, the art of honest, curious observation and the habit of considering the relations of things to each other.

Richard T. Fisher entered Harvard with the Class of 1898, and in due time received his A.B. degree. He was an editor of the Advocate and a member of the O.K. Society and Hasty Pudding club. He specialized in courses in the English Department and graduated with honorable mention in English composition. Those of us who knew him as an undergraduate assumed that he was likely to devote himself to English studies and teaching. As a matter of fact, during the first winter after he graduated, he did serve the College as an assistant in Professor Wendell's and Professor Copeland's courses. But meanwhile an accidental combination of events determined his career. He spent the summer of '98 with a small party that C. Hart Merriam, then at the head of the U. S. Biological Survey, took out for a season of collecting on the upper slopes of Mount Shasta, and

* Thayer was the real originator of "camouflage." During the Spanish War he tried to persuade the Navy Department that a uniform "battleship gray" was not the right war paint for a cruiser—but in vain. By 1914 his ideas had many champions and all the navies then engaged covered their ships with patterns that were more broken and brilliant than those of a wood-duck.

the experience with Merriam, worth more than any ordinary course in zoölogy, awoke in him a realization that what he most desired was some occupation that had to do with nature. Coincidently, while on Mount Shasta, Fisher encountered Gifford Pinchot, who had just become Chief of the Division of Forestry (later developed into the United States Forest Service), and Mr. Pinchot offered him field work for the ensuing summer. Thereafter Fisher continued either in the Forest Service or on leave of absence as a student in the Yale Forest School, until he was appointed Instructor at Harvard. Before he began to teach he had thus been one of the enthusiastic and "closely knit group of men who helped Mr. Pinchot get the practice of forestry under way." While in the Federal Service he had done field work in the west as well as in the east. His bulletin on the coast Redwood, "the first careful study of that important tree," and another bulletin called "The Woodlot," in the preparation of which he collaborated with H. S. Graves, were both brought out by the Bureau of Forestry in 1903. By that time he had also spent some months studying in European forests; and, as a member of the first class regularly graduated from the Yale Forest School, had received his Master's degree.

Although the first few years of teaching look somewhat fruitless from our present point in time, they were by no means wasted; for a teacher learns much, and although the University then had no outdoor laboratory of its own, Fisher was carrying on a consulting practice and could take his pupils to visit woodlots and operations on other people's lands. But his truly constructive period began as soon as the Petersham tract was given to Harvard. The Forest immediately became several things in one,—an indispensable aid to instruction, a field laboratory in which investigations could be carried on and observations could be accumulated without interruption, and a place where new methods of silviculture could be demonstrated. Soon thereafter elementary instruction ceased to be offered at Petersham and no more students were enrolled unless they were already prepared for advanced work. At first, it was the practice to move classes to Cambridge and the Bussey Institute during the winter months, but cold weather accommodations for a few men were later arranged at Petersham. The lack of accommodations for more has limited the annual enrollment of five students.

Most fortunately this tract had not been "skinned." There were, to be sure, treeless or cut-over areas in which experimental plantations could be started forthwith, but the larger part of the tract was covered with a growth in which almost every variety native to New England and every age class was somewhere represented. Profitable cuttings could be made right away without detriment to the whole. Thus Fisher was able, from the very beginning and until the recent depression paralysed business, to administer the Forest as a constantly productive property and to make it pay most of the operating expenses. Inasmuch as he succeeded, while doing this, in maintaining and steadily improving the quality of the woods, he not only kept his peace with University Treasurers who had almost no money to give him, but made the Forest count continuously as an example of practical management.

A forest yields the slowest growing of all crops. When work began at Petersham, hardly any studies of the silvicultural characteristics of American forest trees had yet been made. Public sentiment in favor of conservation had been widely aroused, and a notion that European forests have been maintained by requiring whoever cuts down a tree to plant another, had got itself so widely disseminated that one often heard people say, "We ought to have a law like that." Nurseries, both private and state-managed, were selling seedlings and doing their best to popularize the planting of unbroken stands of conifers. On the other hand the lumber industry was still drawing largely upon the country's remaining supply of primeval forest so that an owner of eastern woodlands, who had any intention of balancing his ledgers on the basis of existing stumpage prices, could not afford to spend much on planting or on the improvement of a growing stand.

In view of such conditions most people would have predicted that it might be fifty or seventy years before any very significant conclusions could be expected to emerge from the work that Fisher was undertaking. He himself realized that he could not hope to make an immediate or sensational showing. More time might be required than would be granted to him during his own life. But he went to work patiently and without letting himself be diverted from what he thought was a wise procedure or a truly instructive procedure by the

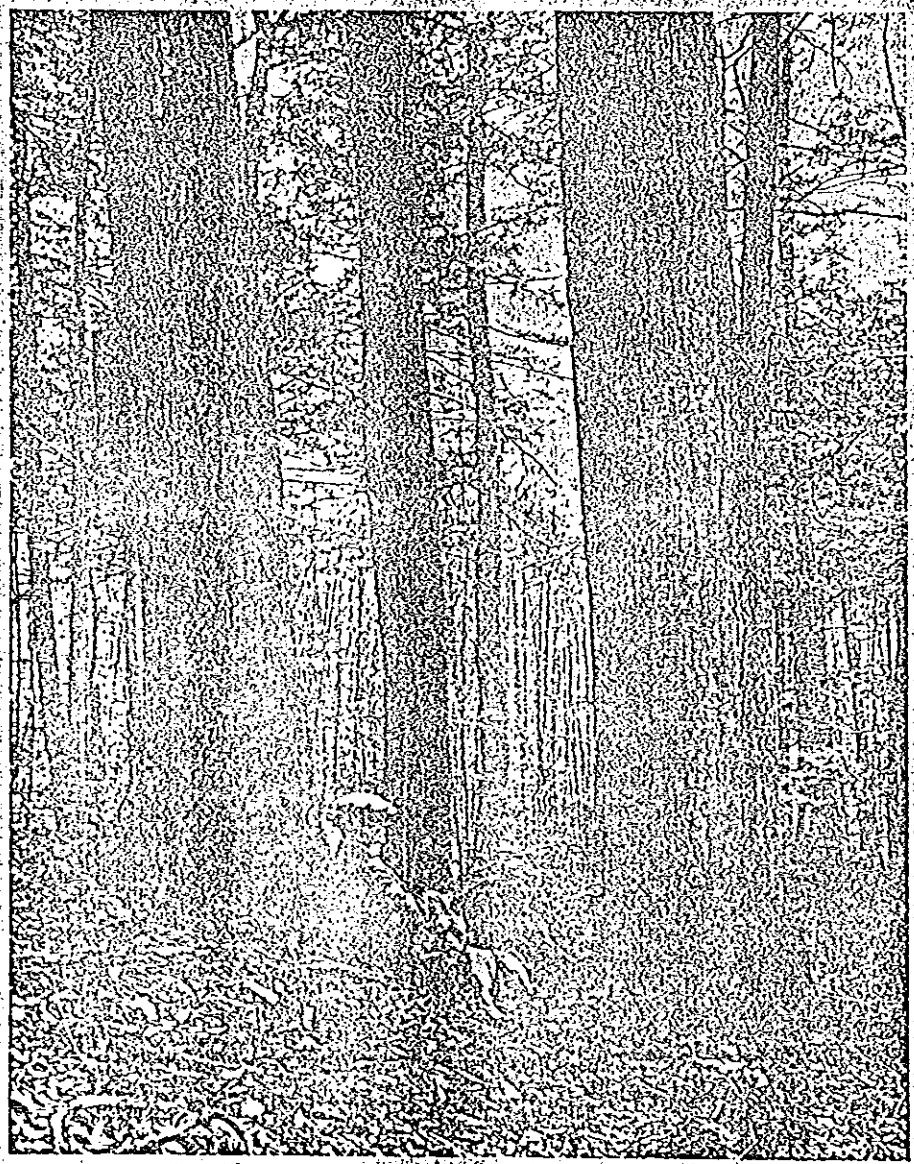


Photo by U. S. Forest Service

Professor Fisher and "Johnny" in the virgin Hemlock and White Pine area of the Barre Woods

temptation to do something showy. And, in the course of fifteen or twenty years, valuable conclusions did begin to emerge at Petersham, and Fisher, who felt a normal craving for recognition, had the satisfaction of realizing that competent professional brethren all over this country and also abroad were welcoming these results and were beginning to discuss their implications. An honorary M.S. that Yale conferred upon him in 1929, pleased him greatly. During the decades that lie ahead of us, as more and more lessons come out of the experiments in the Harvard Forest, those who can understand will realize that they are, to no small extent, the ripening fruits of work that Fisher inaugurated but could not live to complete.

What were the results that were achieved?—achieved, be it always remembered, by the aid of a small though enthusiastic staff and very meagre funds. The question can be answered by citing a few facts and by quoting certain persons whose professional opinions are entitled to respect. I shall speak first of The Forest and professional connections, and last of the students, and of Fisher's personal influence.

Fisher was the first to recognize the importance of distinguishing between those local forest types which are purely temporary and hence transitional in character, and those which contain the elements necessary for stability and permanence. Outstanding among the former when the Forest was acquired by the University was the "old field" white pine type, which has reclaimed the abandoned fields and pastures throughout New England. So prevalent and productive was this type that one can readily understand, and forgive, much of the early propaganda that advocated planting white pine in pure stands, anywhere and everywhere. Fisher was one of the very first to see that an undergrowth of desirable hardwoods invariably became established under the pine canopy in advance of logging, and that, with equal certainty, this hardwood formed the bulk of the next volunteer crop. Recent studies have shown that fully eighty per cent of the area formerly occupied by "old field" pine now supports mixed hardwoods. With the very first cutting on the Forest, in 1908, Fisher began a quarter century of intensive study of the white pine-mixed hardwood succession, gradually evolving a complete system for replacing a temporary type, inherently poor in quality of product and

inimical to the maintenance of soil fertility, with a mixture of hardwoods of potentially high quality, possessing marked soil-building properties and a maximum of security and stability, all without recourse to planting.

Prior to 1920 American foresters, generally, paid little attention to a very definite link between the condition of the soil and the trees growing thereon. They had usually accepted forest soils as being simply good, bad, or indifferent. Fisher's early observations sharpened his interest in this and a visit which Dr. Henrik Hesselman, Director of the Swedish Institute for Forest Research, made to Petersham led him to focus attention on the problem of soil relationship. With the collaboration of Professor P. R. Gast special investigations were undertaken. Fisher emerged with an entirely new view point. It is owing to this that the Harvard School is to-day carrying on its fascinating researches in this field. And it is also on this account that similar investigative projects are being furthered at the Black Rock Forest. It is fair to say that Fisher stimulated a new and essential interest in forest soils.*

The Forest has acquired a reputation, both within and beyond the boundaries of the United States. Mr. P. M. Barr, Chief of Research in the forest service of British Columbia, wrote in 1928 that it offered "more in the way of instruction and inspiration than any place he had visited." Dr. von Maltzahn, of the Mecklenburg Forest Service, said in that same year that he considered it the most instructive example of forestry in America, and added that if he were looking for examples of applied silviculture on this side of the Atlantic, he would mention one word: "Petersham!" Mr. R. S. Schonland, of South Africa, wrote to Mr. Fisher after his visit in 1927:—"I really do not think that I was ever able to collect so much information in so short a time." "Forest News," edited at the first thorough-going School of Forestry which was established in this country—that at Yale, where Fisher took his own M.F.—recently said that at Petersham

* For guidance in making the statements in this and the preceding paragraph I am indebted to Mr. A. C. Cline of the Harvard Forest, Mr. H. H. Tryon, Director of the Black Rock Forest, and Dr. Austin Cary of the U. S. Forest Service. It has further been my privilege to read a large number of letters from men of professional standing and competence, some written before Fisher's death and some since; but unless I quote them directly, it seems unnecessary to retail their names.

the "record of continuity in intensive silvicultural practice is probably unequalled in America and it is to the cumulative results of this management that Fisher's contribution to forestry owes its great value. . . . The Harvard Forest gives to the profession that which is most needed now and which will continue to be our most urgent requirement for decades to come—a demonstration area where the actual working out of forestry practice as a successful business venture can be studied at first hand without having to visit a foreign country to convince ourselves that it can be done."

During the last few years Fisher and his assistants and an unnamed friend of the Harvard Forest have been making plans for a little museum at Petersham, and have been preparing exhibits in the form of scenes like the "habitat groups" that have been beautifully installed in the New York Museum of Natural History. When these are completed and shown, I am confident that they will be found to convey both historical information about the evolution of our New England forests and practical information about methods of management in such a revealing fashion as has never been before.

In addition to the work that was done on the Petersham tract itself, extension work that was carried on by rendering consultative services has undoubtedly been important. Fisher established advisory relations with a long list of private estates, lumber companies, woodworking industries and corporations controlling water supplies. Many of these people were skeptical and distrustful at the outset. Hard headed operators couldn't have been expected to approach forestry in any other spirit. Tact and salesmanship alone could never have won their respect. But Fisher convinced them that he could make their problems his, and that he had common sense to offer as well as knowledge. By means of these connections the range of experiment and experience open to the staff and students at the Forest was widely extended, and on the other hand the staff of the Forest was enabled to exert an active influence in the determination of methods of management.

The officers of the Massachusetts Forestry Association leaned on Fisher for advice. Although I think he seldom appeared at legislative hearings, he had a great deal to do with the formulation of all the early laws concerning forest matters that were enacted in Massachu-

setts, and he was especially helpful in connection with the forest taxation law of 1922 and the establishment in recent years of town forests.

Although a forester has to be rigorous about costs and returns, just like a thrifty farmer, Fisher was quite clear about the fact that a forest, enduring as it does for decades and perhaps centuries, should yield other benefits to the community besides logs and cord-wood that can be turned into dollars. It affects a water shed and the local atmosphere. It transforms its own soil. It harbors different kinds of game, according to its type, and similarly birds and beasts that matter to the farmer. The woodlands offer opportunities for recreation, and inasmuch as American tax payers will have something to say about the rapidly increasing number of Federal, State and town forests, it would be a practical mistake as well as a pity to overlook æsthetic values. All sorts of considerations should be taken into account. It was often a delicate matter for the Director of the Harvard Forest to maintain happy relations with the Petersham community, composed, as it is in part, of tax paying farmers who might easily be troubled by the withdrawal from the tax rolls of a large tract of land, and partly of summer residents who are inclined to be sentimentally resentful when handsome trees are felled. Both Harvard and Petersham will remember with gratitude that Fisher was endlessly patient and considerate about the relations of the Forest to its neighbors and to the town. So important was this that it seems relevant to note that Fisher went further and took such a part in the town's own affairs that he became one of its leading citizens.

The people of Petersham could see that he was not a new fangled kind of lumber man, but a fellow townsman who loved their countryside and cared about the general welfare no less than they did. They were aware that, like some of themselves, he was a good fisherman, an excellent rifle-shot, and a true sportsman. The Petersham Country Club's recent resolution on his death is worth quoting:—"The golf links of the Club are the result of his imagination, of his enthusiasm, of his practical genius, and of his untiring effort and continuous care. The spirit and sportsmanship of the Club were fostered by his friendliness and his example. The Club can never regain in a single person what it has lost by his death." When, recently, the State Highway Commission proposed to straighten and widen the highway

passing through Petersham, Fisher's promptness, ingenuity and tact contributed largely to the adoption of a plan that will swing the road past on a detour and spare the village.

Apart from the development of the Forest and its affiliations with the local and the larger community, there was always the teaching. It will be recalled that elementary instruction was not given after 1907 and that since then the Forest has been a station for research where only a few men at a time have been accepted as students. About ninety of them have now received the Master's degree in Forestry on Fisher's recommendation and about thirty-five more have studied at the Forest without taking degrees. Modest as these numbers may seem at first glance, they represent a considerable contribution to the ranks of a small and young profession. Furthermore the contribution appears to have been a significant one. How generally the graduates have stuck to the profession is indicated by the fact that more than sixty of them are members of the Society of American Foresters, and at least twenty are engaged in research. One is a Senior Lecturer at Melbourne University; another is Director of the Pack Demonstration Forest at Warrensburg, New York; another is Director of the Black Rock Forest. One is Chief of the Indian Forest Service in the Interior Department; two are heads, respectively, of the New York and Massachusetts State Forestry Departments. Some are filling other positions of high responsibility in the Federal and State Services, and others are professors or instructors in Schools of Forestry or are leaders in the profession at large. Professor H. S. Graves, Director of the Yale School of Forestry, writes ". . . I regard Fisher's work in education as one of his largest contributions to forestry. He properly resisted the idea, still held by many, that a practical man with a moderate knowledge of forestry can meet the requirements of the profession. The great influence which the Harvard Forest has exerted and will continue to exert is derived from the high standards in education which Fisher set, from the character of his teaching, and from the vision of the broad significance of forestry in our national life which has been emphasized at the institution."

Such facts are what might be called the records of achievement, but it would be wrong not to speak of something that Fisher brought

The site of the Fisher Memorial by Tom Swamp Pond

to all his tasks and into all his relations with his students. I refer to certain personal qualities and to the influence of his own example. All the notices and letters about him that I have seen since his death remark on these things. Mr. Tryon adds to what I have already quoted from him: "I think his greatest gift to men like myself was the inspiration of his quiet, humorous, unceasing enthusiasm." Dr. L. G. Romell, a Swedish soil scientist, writes: "He had more of that biological feel for and with his forest than is usual with American foresters in particular. This, to my mind, is a very essential thing for a silviculturist and forest ecologist,—so essential, indeed, that only men gifted with that feel can be expected to show the way to newer and truer methods in silviculture." Another says:—"My own feeling on the subject of Professor Fisher's service to the profession is that his greatest contribution was the elevating and refining influence of his own character and personality and his philosophical and far-sighted approach to the innumerable problems that confront every new profession."

When Fisher was young he went about in a perpetual state of moral and æsthetic ebullience, quoting Wordsworth, Shakespeare, his uncle Abbott Thayer, Thoreau or R. L. Stevenson—the latter more than all the rest, for during a certain youthful period Stevenson came near to being his divinity. We used to laugh at him, and he would then join in the laugh with entire good nature, and the next minute he would invite us again to flutter upward toward the empyrean. Time (which means age), a happy marriage, children, family cares and innumerable work-a-day duties quieted him and hardened his gristle. The inner warmth remained but the ebullitions died down and, strange though it may sound to anyone who knew him only as an under-graduate, he became rather reserved. An anonymous correspondent of the *Transcript* has recently referred to him as "an idealist with the love of beauty so completely filling his life that in spite of his great gift of making all men his friends, he seemed a little apart from them all." This correspondent adds:—"A quiet dignity was his, and the real simplicity of a philosopher who looked for the good in all things and generally found it."

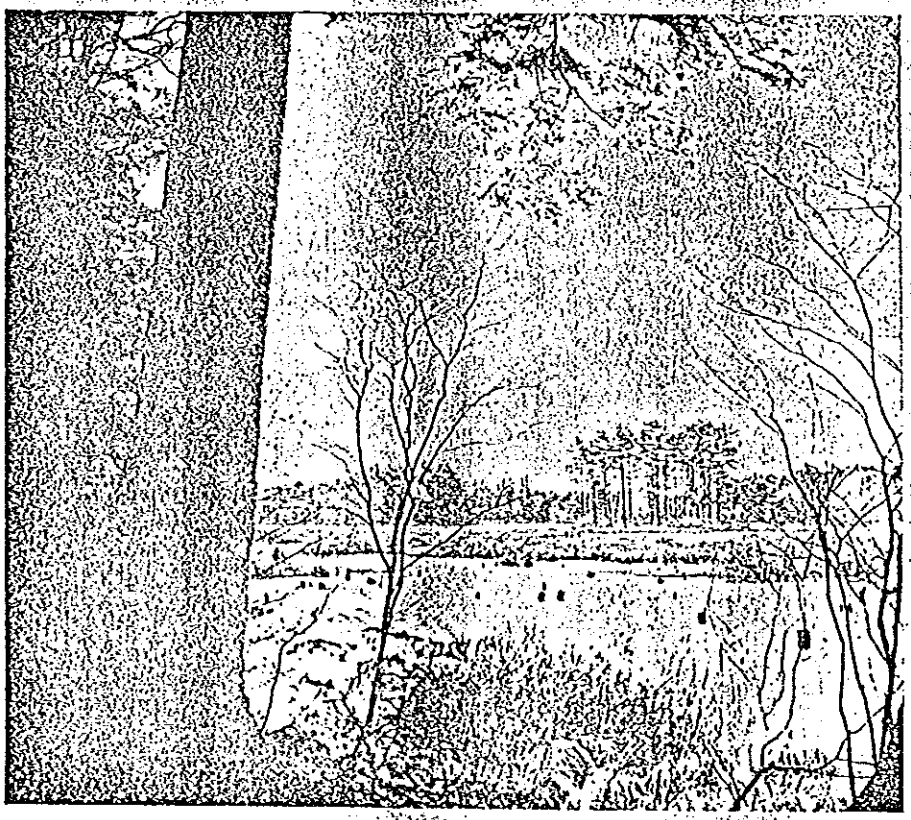
If I may offer my own testimony, I would add that he was the most interesting and delightful out-of-doors companion whose com-

pany I have ever enjoyed. He saw the sunlight at play among the leaves as well as the forms of the foliage. He noticed everything that went on about him and his mind was discursive rather than just systematic or analytical. Birds and beasts, plants and trees, earth worms and soils, streams and ponds and the history of the transformations that have been wrought on the New England hillsides—such matters were not divided and distributed into special compartments in Fisher's mind. Their interdependencies were as interesting to him as were their separate idiosyncracies. Although he looked like a professor—bald head, little blond beard, spectacles, and often a ruminative look in his blue eyes—he was not a bit pedagogical. He did not try to exhort or instruct; he wasn't forever dragging forth the nomenclature and technicalities of a specialty while leaving it to others to relate it to the realm of one's ordinary interests. Quite the contrary, he went about as if asking for nothing better than to take a walk and enjoy the scene. He entered into your interests, and not until you were wise enough to turn the talk upon what you found in the woods, did you begin to draw out his special wisdom. What he then imparted had the quality of suggestion rather than the quality of doctrine. Not that he was vague or inaccurate—to give that impression would be quite wrong. But his imagination was active, and it seemed to envelope any discrete splinter of reality in a halo and penumbra of fascinating relationships, discernible or still to be explored.

There lies before me a letter from a friend of Fisher's—not a forester it so happens—who knew him intimately for thirty-five years. "I did not realize until lately," he writes, "how much I owed to Dick. From those early days he opened, somehow, for me the doors of romance. Fields that were without limit. First of all in music. In biology, and everything that had to do with nature. To some extent in literature. And always he was on the side of appreciation rather than of criticism. He became a part, or a possible part, of all my recreations. (Incidentally he was my most sympathetic audience. He believed in me.) I shall miss Dick, but above all I shall miss what he understood and appreciated. The world and the sunlight seem poorer without his response." If the writer of these sentences were to be reminded that Dick Fisher didn't know a great deal about music

and was quite ignorant about vast areas in the field of biology, he would admit it, and would add:—"That didn't matter."

We learn most readily from those we revere and love. The seeds of their teaching fall upon soil that is already warmed and hospitable, and they are the ones who most often help our natures to unfold and



Tom Swamp Pond seen from a point near the Fisher Memorial

expand. After all, perhaps there is nothing more important to record by way of justice to Fisher's memory than that he possessed qualities which thus add immeasurably to a teacher's power of doing good. Although I doubt whether he was able to make himself count effectively in a formal classroom, I am sure that he shone at Petersham, where from day to day he and his assistants and pupils shared each other's work in an informal comradeship. So little of his time was

spent in Cambridge, so few officers of the University ever visited Petersham, and so very few of his students were graduates of the College, that the Harvard Community can hardly be expected to realize what he did or to perceive where his labors are bearing fruit. The men whom he trained and who were influenced by his spirit have entered a profession that is new in America. Preceded and led by only a dozen or so of his own contemporaries, the generation of foresters into which his pupils have been recruited will have to be reckoned as the pioneer generation.

Naturally Fisher had his troubles and his disappointments. But he never had a crushing sorrow to bear, and I think he would agree that his life was unusually happy. Sympathy and the companionship of people whom he could like and respect, which were very necessary to him, were offered him in good measure; for in addition to his own family he had a small host of friends. He was convinced that the work in which he had engaged was worth doing and knew that he could do it well. He enjoyed doing kind deeds and giving out sympathy and encouragement to others. And he always kept his eyes and his heart open to the beauties of both the visible and the invisible worlds.

HENRY JAMES, '99

August, 1934. *

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*The Harvard Forest, 1907-1934: A Memorial to its First Director, Richard Thornton Fisher, published by the Alumni of the Harvard Forest (Cornwall Press, Cornwall, N.Y., 1935), pp. 1-15.

METHODS OF INSTRUCTION IN THE FOREST SCHOOL.*

By R. T. Fisher.

The work of the American forester is (and will be) primarily concerned with the management of commercial timberland. There are many problems not directly commercial which are also properly within his field, but it is clear that the successful development of forestry in this country turns on the ability of foresters (or whoever handles the forests) to perpetuate the forest industries. Lumbering has got sooner or later to become forestry, but its progress toward that end is fundamentally controlled by economic limitations.

These facts, though commonplace enough, underlie the determination of methods of instruction in the Forest School, and indicate one of the prime needs of the forest student. Any one who has had a few years experience of forest work in a particular region cannot fail to have realized that the successful lumbermen owe their success largely to a knowledge of executive and mechanical detail, from the efficiency of labor to the varieties of saw practice, that has taken years to acquire, and which has crystallized into a large and complicated organization. It is businesses of this character that the forester is expected to prescribe for, to improve, and sooner or later, as conditions change, to reorganize. How, then, should the Forest School prepare him for his work? It should plan its teaching on the assumption that just as medical practice is based on the anatomy and physiology of the body, so forestry must be based on a no less through grasp of the lumber business, that is, the mechanical and administrative principles which are involved in the harvesting of timber. Whatever degree of sustained productiveness a forest may attain, its manager will still have to make roads, organize crews, and get logs to market—in other words, control the machinery by which forestry is to be carried on.

In planning the training for this purpose, it is apparent that

*Read before the Conference of Forest Schools, Washington, D. C., December 30, 1909.

within the usual limits of a forest curriculum not all American lumbering can be effectively studied. The best scheme would seem to be thorough instruction in the methods and conditions of some one typical region, with a more general consideration of the business over the rest of the country. This involves on the part of the Forest School the possession or control of a large tract of forest land in which lumbering operations on a scale typical for the region can be annually carried on. If possible the forest ought to be so situated, with regard both to composition and value, as to make a high degree of intensiveness in management possible. In that case it can be organized under a working plan, the operation of which may involve and exemplify a variety of scientific methods. The forest then becomes, as far as its business development will permit, the backbone and background of professional instruction, and the key to the understanding of problems in other fields and regions. In its relation to the school it has the following functions: First, it offers a field for thorough grounding and practical experience in a representative lumber business. Second, it furnishes the laboratory for training in technical forestry. Third, through the accumulation of records, both those connected with the operations and those arising from research, it becomes an instructive experiment station.

With the demonstration-forest in its possession, the school ought then to correlate the various courses and organize its teaching so that lumbering on the one hand and technical forestry on the other, while developed in their elements and principles separately, should enlarge and illustrate each other. In other words, the science of forestry as developed in practical instruction should be under constant test of applicability, first to the particular business in question, and later to those typical of other regions. This is not in any way to limit or narrow the highest technical training or the inculcation of the broadest ideals of forestry, but rather to aid the student in remembering by connecting principles with their uses. The arrangement and sequence of courses, while admitting of a good deal of variation, fall naturally into a number of parallel lines, each including, in logical order, those subjects which grow out of each other. The main and central line would be lumbering,—logging, transportation, sawmilling, market, and manufacturing, in detail for the home operations, more generally for the business elsewhere. The other lines of development,

based whenever possible on forest work itself, are (1) Dendrology, Silviculture and Protection, (2) Forest Survey and Mensuration, Management, Administration, and Policy, and (3) Wood Structure, Technology and Products. As a means of instruction the order here indicated ought, at least roughly, to be followed.

When it comes to the actual teaching and how to do it, there may conceivably be as many ways as there are good teachers. Yet leaving aside the personal gift, and assuming a complete and logically arranged curriculum, it is possible to indicate a method of developing subjects, imparting information, and accomplishing training which is more or less applicable to all parts of an education in forestry, and which is already proved and established in other professional schools, such as those of medicine or mining. This is a method resembling both the "case system" in use at many law schools and the clinical system in medicine. It has been the experience at Harvard (and it has strenghtened our belief in graduate instruction for the scientific professions) that the professional attitude of mind can be awakened best by requiring some initiative on the part of the student, making him do some of the teaching himself. Thus, in many professional courses, the work consists primarily of a series of cases or problems from which the student is expected, in some degree, to derive the principles himself, and on which the instructor's lectures may be as much quiz and comment as regular exposition.

In adopting such means in the teaching of forestry judgment must of course be exercised in fitting them to the subject in hand. Such necessary modifications would naturally occur to any instructor who was well grounded in his subject. So far as the method is applicable to forest education in general, it consists, first, of lectures so given as to develop the subject logically and make the student himself think and assimilate; second, regularly assigned exercises or problems, arranged so as to follow the evolution of the course, and the results of which, especially the principles involved, have to be embodied in reports; and third, as far as it exists, both text-book and collateral reading. A few examples will show how the scheme works out in particular cases. In silviculture, for example, general lectures on the factors governing forest distribution and the association of species, supplemented by reading, are accompanied by connected field

exercises as follows: Topography over an extensive area and classification into distinct features or sites; soils, identification and physical analysis as related to formation and site; local forest distribution as related to soil and site and separation into types; the single type, its composition in detail; the silvics of the species as indicated by the life history and form of the stand; and so on through a more or less coherent series of assignments leading up to extended practical work, such as marking for various kinds of cuttings, and independent silvical studies. In a similar way instruction in lumbering is developed. The class is put to work in each part of the operation as it occurs, divided up among the regular crew, beginning with felling and ending with mill work. In each process the aim is to make the student find out by sufficient experience not merely average costs (which are misleading at best), but the actual factors which affect efficiency, economy, and cost. Thus, to illustrate by the work in felling, he is expected to learn and to set down in his report, not only the ordinary mechanics of cutting down a tree and the capacity of a standard crew per day, but such points as the relative loss or gain, in money and per cent. of volume, depending on the angle of the undercut, the position of the saw cut, and the height of the stump. Forestry, in its execution, can not differ essentially from other woods work in being largely a matter of good organization and small economies; and it is points like these that train a man's executive judgment and open his eyes to the needs and chances for better and better methods. With a knowledge of such details and the principles underlying them, the professional student has, for one type of business, something resembling the practical lumberman's hard-won insight. This should serve both as the groundwork of later instruction in general lumbering and forest engineering, and as a guide and help to the prompt understanding of essentials in any new region. If throughout the whole of his technical education, no less in silviculture than in logging, the student is thus made to deal with facts and cases, to derive principles, and to show his own results, he will have acquired some of the capacities which his future work will demand.

As far as instruction and training will suffice, the Forest School should have trained a man upon graduation to the possession of certain definite and necessary qualities or abilities. In the first

place, he must like and understand how to live rough a fair share of the time. Forestry is not a refuge for the unfit, and for their own sakes as well as that of the profession, such men should be weeded out early in their course. In the second place, he should have executive understanding of the organization of all important branches of woods work. Many lumbermen of no technical training are already making some of the very improvements in method that forestry should be able to furnish, and if the forester is to win his place in such work, he must first know the business in question, and have some idea how it is controlled. Third, he must be able to make investigations of scientific value, whether on the business or the technical sides of his work. Involved in this are the power of quick and accurate observations, and of being able to record them in clear and workmanlike reports. The command of writing constitutes almost the only advantage of the forester over many experienced cruisers, who are often able to estimate timber more cheaply than he can, but lack the training to make an intelligent statement of facts. Finally, he should have the broadest outlook on the relation of forests to national economy that the fullest technical training can give him. It should not be enough that he should prove useful in some of the immediate problems of present day lumbering, although that will often be the test of his success: he must be equipped for a scientific development of forestry which, though it may be difficult to forecast in detail, is none the less certain to come.

SOME UNWRITTEN RECORDS IN THE HARVARD FOREST.

PROF. R. T. FISHER, '98.

Of the various faculties which the forester is called upon to acquire, an instinctive insight into the past and future of forests is professionally one of the most useful and unprofessionally one of the most entertaining. He must be able, in the converse of the common saying, to "see the forest for the trees." This involves conceiving it in imagination as a living crop, whose history and prospects, as revealed in the complicated relations of the trees which make it up, may cover several centuries. Thus, as fast as the forester learns the habits of the different species, how big a tree should be at a certain age, how it looks if it has grown in the open, and how if in the shade, and the signs of all the injuries and diseases and other "acts of God" that occur in the woods, just so fast his mere visual image of a multitude of trees brings with it an imaginary picture of the way the forest looked, or would look, in all its stages, from the germination of the seeds which produced it to the final picturesque and massive decline of the primeval wilderness. In other words, by numberless signs he can decipher the date and manner of its origin, its probable longevity, and its past vicissitudes, whether due to man or the elements.

Interpreted by such a key, the Harvard Forest furnishes some interesting records of the human occupation of the town of Petersham, and in fact of much of the upland region of central New England. A person looking over the country from a hill-top would be struck with the large proportion of forest to cleared land. At least four fifths of the area visible for ten miles in every direction is woodland — and to the casual eye, woodland of very respectable claims to the title of forest. Yet except for a few small tracts, none of it is more than seventy-five years old, and the great bulk of it started life between forty and sixty years ago. In the bird's-eye view there would easily be picked out certain dark patches known in the parlance of forestry as pure pine stands; and in many cases these would be seen to be noticeably geometric or straightsided in shape. Such stands, owing to the seeding habits of the white pine, originate only on cleared land — pasture, old field, or in rare cases, burn. On the Harvard tract, most of them are between fifty and sixty years old. In the absence of evidence of fire, these blocks of pine thus fix the approximate date of a general abandonment of farm lands — lands still further identified as such by the incongruous lines of stone walls and occasional cellar-holes now buried in the woods.

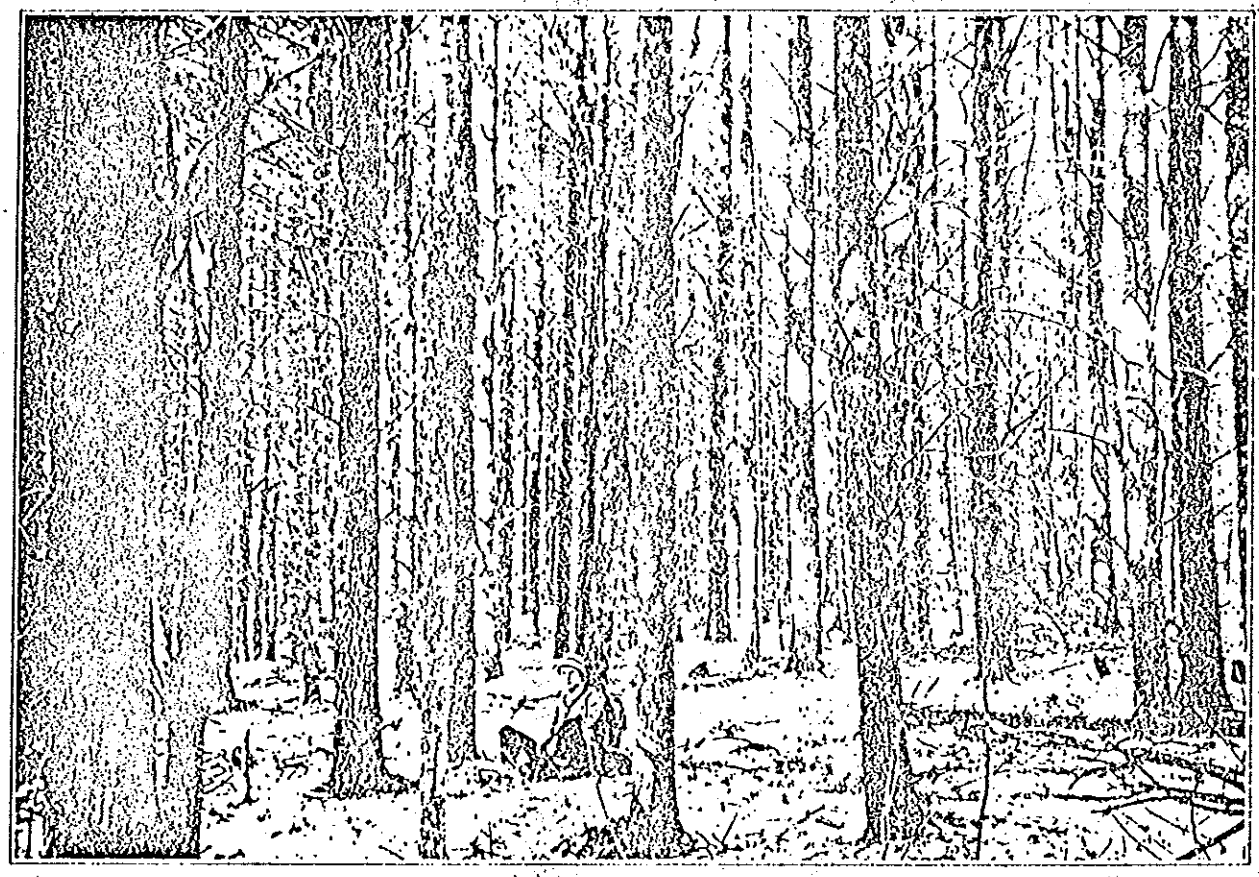
Other types of forest, indicating still other dates and conditions of ori-

gin, would serve to complete a chronology of other, less extensive changes in human occupation, both earlier and later, and already, doubtless, of record in New England economic history. But the main shift or decline of population is most clearly recorded in these pine stands, and by their evidence is shown to have occurred in one comparatively short period. In the first half of the last century, the population of Petersham, in common with that of many neighboring towns, was double its present figure of something over seven hundred. Various causes operated to start the decline, — the building of the Fitchburg Railroad, the development of manufacturing towns, and the opening of the West. But to judge from the age of the prevailing pine woods, it was for the defense of the Union that the farmer finally abandoned a failing livelihood.

Concerning remoter colonial and pre-colonial days, the silvical records are much scantier and more obscure. One of the investigations now being conducted on the Forest, and growing out of the accumulating knowledge of existing woodland, is an attempt to reconstruct, largely from evidence on the ground, the character and distribution of the original forests of central Massachusetts as the first settler found them, and to trace the modifications brought about by the use of the land. Aside from exploration and the pursuit of Indian war-parties, the first white occupation of the region took place between 1700 and 1740. At that time probably ninety per cent of the land was covered with heavy forest. By 1850, fully three quarters of the forested area had been cut over at least once, and over half of it cleared for farms. Add to the labor of this undertaking that of constructing some thousands of miles of stone walls, and one gets a just idea of colonial industry. After the war-time emigration, the forest flowed back over the fields, so that today there is nearly twice the area of woodland there was in 1850, and at least as much as there was in 1800.

The effect of these alternations of use and disuse upon the forest has been to eradicate all but a few remnants of the original pre-colonial stands — so few and small, indeed, and so generally passed out of mind, that the forest monarchs among which Cooper's Bumpo threaded his unerring way are all but legendary. The Harvard Forest contains one such remnant — a piece of several acres in extent; and though single trees have been culled from it in old times (usually the biggest ones), it still preserves some of the look of age and loftiness that only the ancient forests have. The striking thing about the stand, in contrast to the comparative monotony of "second growth," is its commingling of antiquity and youth — the intermixture, in every variety of grouping, of saplings and mature trees, of the largest veterans and the smallest seedlings, and of all the living with the crumbling windfalls and naked "snags" that are slowly yielding to lightning, wind, and decay. Every gap left by the fall of the aged is steadily filled by the younger trees, and although growth in the crowded spaces and obstructed light is slow, it is enough to keep the general appearance unchanged, which is a condition characteristic of forests that have never been touched by axe or fire.

In the Petersham sample, the age of the oldest living tree goes back to the very early eighteenth century, and of the dead to considerably earlier. The shape of many of the tree-tops and the vestiges of stumps show that a century or more ago some of the largest dominant pines were cut, which lowered the average of size but did not greatly alter the constitution of the stand. The days of these selective cuttings were the days of the ox-team and the brookside sawmill with its monstrous overshot water-wheel — and the days, too, when the fruit of their deliberate labors became the unrivaled woodwork of the colonial house. The foundations of such a mill are still standing on the stream close by, and in the village much fine paneling bears witness to the quality of its product. Thus, quite apart from its picturesque and scientific value, this fragment of old woods is a most significant relic, which helps to bridge for the physical eye two centuries of unpictured alterations in the face of the country. It preserves a scene which the earliest settler took, and transmitted without substantial change, direct from the bear and the Indian.



IN 1861 A PASTURE, NOW A PINE FOREST NEARLY SIXTY YEARS OLD.

Bulletin 123

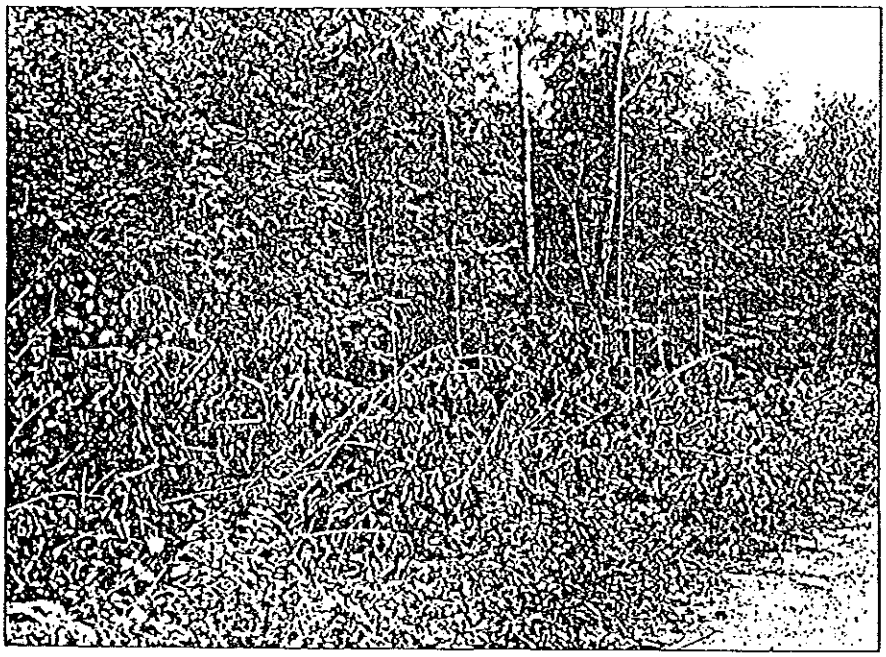
MASSACHUSETTS FORESTRY ASSOCIATION

SILVICULTURE FOR COUNTRY ROADSIDES

By Richard T. Fisher, Director of the Harvard Forest, and Tree Warden of Petersham

A Suggestion to Tree Wardens and Highway Surveyors

ALONG most country roads there is a strip of unused land between the edge of the road bed and the boundary of the right of way which requires, from time to time, a good deal of attention from the local tree warden or highway surveyor. Except in thickly settled neighborhoods, these roadside strips, commonly about a rod and a half in width, grow up to a tangle of woody vegetation which, in its early stage, is usually known as "brush." From time to time these thickets grow and spread to such an extent as to restrict the use of the highway, especially for heavy loaded traffic. It then becomes necessary for the road crew or tree warden to "brush out" the roadside. The ordinary way of doing this is, to a large extent, a waste of money, because the improvement brought about is only temporary, and when the next operation falls due, it is more costly than the first.

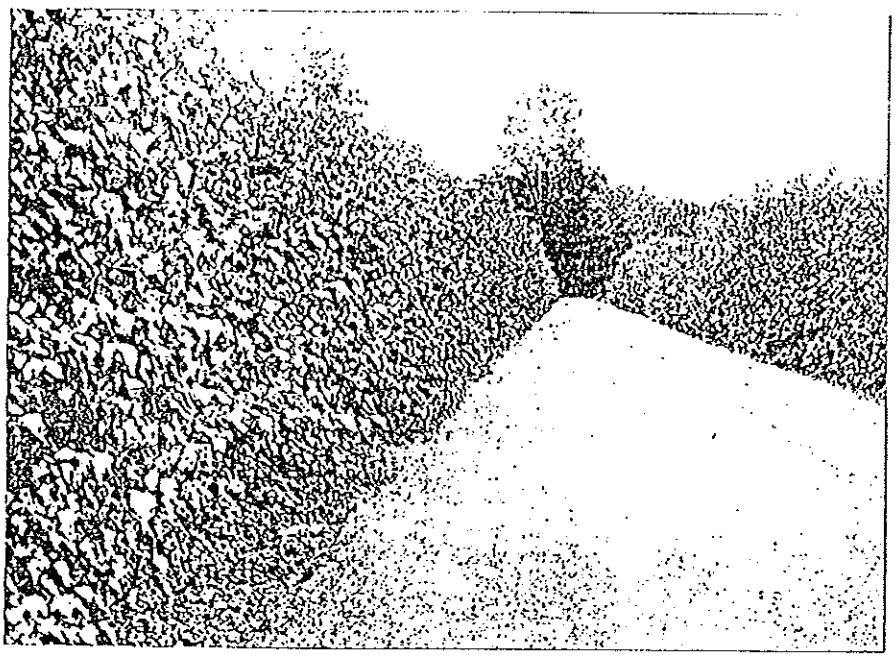


VIEW NUMBER ONE

View Number One shows a typical roadside immediately after the highway surveyor has finished "brushing it out." As the picture shows, all vegetation is cut clean from the road to the boundary of the right of way. In some towns, the material cut is left where it falls or half-heartedly thrown back, notwithstanding the fact that the law requires it to be disposed of as a precaution against fire. Furthermore, the appearance of the roadside is anything but improved and the prospect of any effective shade is postponed a number of years. These results, however, are not the most important, either from the point of view of town finances, or the traveling public.

View Number Two shows how such a roadside looks three years after it has been "brushed out." Practically all the woody vegetation which was cut

in the process, has sprouted from the roots, sending up several stems where one grew before. The most worthless, such as grey birch, alder, or poplar outgrew all the more desirable and long-lived species, and the general rate of growth of the new thicket is



VIEW NUMBER TWO.

from two to five feet per year. Thus in so short a period, there is an even denser barrier beginning to crowd the road, and the species which compose it are still more predominantly of the kinds that could never make a desirable roadside tree.

What are the objects to be aimed at in the public care of a country roadside? For the ordinary small town, perhaps the first is economy, a condition which, while admitting the best use of the highway, can be maintained with the least expense. Taking the whole year together, there are a number of seasonal and climatic factors that must be considered. In winter, it is desirable that the road should hold whatever snow may fall and yet be free from drifts. For teamsters much on the road, a certain amount of shelter is also welcome. In spring, a road should be enough exposed to sun and wind to dry out quickly. In summer, whatever tends to reduce the washing due to heavy thunder showers, and to prevent the formation of the deep dust that comes in long, dry spells, is a good thing. Finally if all these favorable conditions can be attained, it is surely worth while to have a roadside that is pleasant to travel along and attractive to look at. All these benefits can be secured if the natural vegetation, instead of being fought, is intelligently favored.

View Number Three shows what may be expected if this is done. This road has not required the expense of a dollar in keeping down brush for the past fifteen years. And even the road bed itself has been conspicuously more durable by reason of protection from weather. On this roadside, there are just enough trees to make a complete shade for the ground beneath, without covering the road itself. The effect of this has been that all the small vegetation, weeds, and underbrush has been killed by the continuous shade, which is the only practicable way in which such growth can be killed. The existing trees are sufficiently free from lower branches to allow some air circulation across the road and to make it possible to see out on each side across the country. All the snow that falls lies level without drifting, and does not melt off nearly so rapidly during a thaw as where no trees exist. Lastly, the road is shady in the summer, and sheltered in the winter, and it is largely self maintaining—as to the roadside alone, wholly so. Once such an arrangement of trees is established, it should keep the roadside in satisfactory condition for fifty years.

To bring about these conditions, it is not necessary that the official in charge of the roadsides should go to any additional expense, but merely that he should leave standing a sufficient number of the right

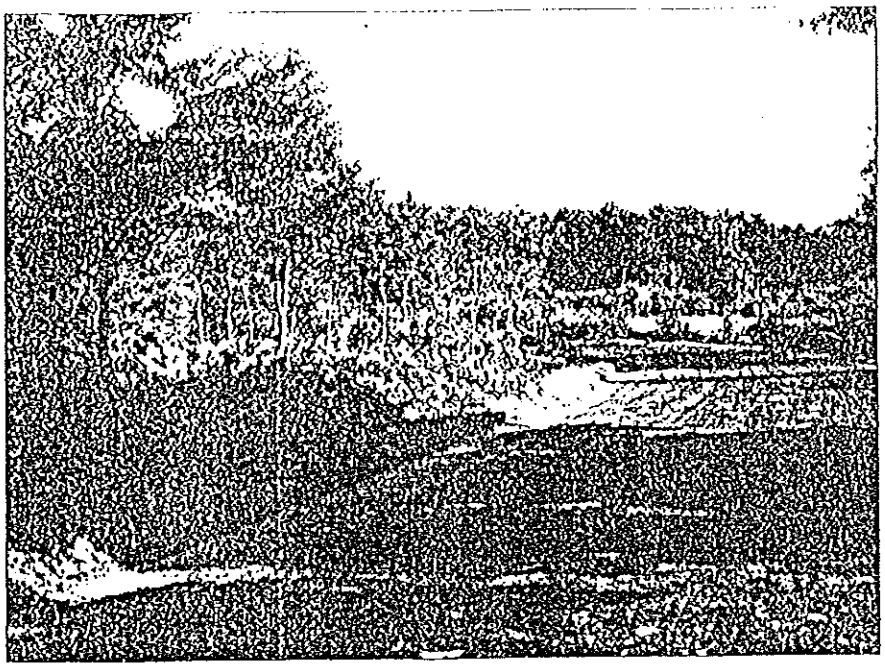
kind of trees so that in time the two sides of the right of way will be continuously shaded. Anyone who takes the trouble to examine carefully a roadside thicket will discover that there are almost always mixed up and partly concealed in the general vegetation a considerable number of seedlings and small saplings of the different kinds of forest trees. It is chiefly because many of them are slower growing in early life than the worthless species that they are so apt to be at that time unrecognized. The only additional cost in "brushing out" a roadside properly is the labor of picking out and marking the trees which should be left standing. Where the general average of the growth is less than ten feet high, the aim should be to leave enough trees on the strip, so that they will not be more than fifteen feet apart, and scattered fairly evenly over the rod and a half of roadside. When these trees have reached a height of forty to fifty feet, there will, of course, be not more than half as many in thrifty condition. The object of leaving them closer together at the outset is to bring about, as early as possible, the complete overhead shade that will begin to kill out underbrush. Under these circumstances, it would be a good thing to cut out about half the number of trees originally left, soon after their tops have begun to interlace. Nevertheless, if this is omitted as being too costly, the trees will gradually thin themselves and steadily maintain shade for the ground.

A good way to manage the first cutting is for the foreman to tag the trees that are to be left standing, by tying on small bits of rag or colored string. These trees should be trimmed up at least as high as a man can reach, and none should be left standing within three feet of the edge of the road. With these restrictions, it is simple for the crew to cut out all the rest of the trees and underbrush. If a second cutting should have to be made within four or five years, the trees left in the first operation will, by that time, be large enough to be recognized and spared without marking.

Not all species are equally desirable as roadside trees. They differ as to their habit, rate of growth, permanence, resistance to insects and disease, and effect upon the road. White ash and red maple, for example, are not eaten by the gypsy moth, and are otherwise apt to last well on the roadside. Less resistant but good are elm, sugar maple, beech, yellow birch, and red oak. Grey birch is not desirable because it is easily bent over by snow and sleet so as to obstruct the road. Poplar, though better than nothing, is a short lived tree and subject to fungus disease. Chestnut is no longer worth counting on, because practically certain to die of the prevalent chestnut disease. White pine is an excellent species for a roadside, but should not be allowed to grow near enough to hang over the road itself. White pines which overshadow the road prevent much snow from reaching the ground, and cause troublesome bare spots long after there is good sledding elsewhere.

VIEW NUMBER THREE

The same is true of other evergreens, all of which are but little attacked by leaf-eating insects and generally hardy. However, in the country districts, the choice of species is not of the first importance. The essential thing is to provide enough fairly long-lived trees to make overhead shade for the ground, and thus to avoid the frequent expense of keeping down underbrush and sprouts. View Number Four shows a roadside just after having been treated according to this method.



VIEW NUMBER FOUR

In preparing this article for the Association, Professor Fisher had in mind primarily, the work of the Tree Warden and the Highway Surveyor, but we believe that many of our members and others can apply these principles to good advantage to private ways and other places where "brushing out" is required.

At this time when municipalities are economizing in every way possible, probably little money will be spent, in planting roadside trees, but some brush cutting will have to be done. Proper thinning of brush in most cases is equivalent to planting trees. Therefore, we feel that this article is timely, and should be given careful consideration by those in authority in towns.

To many people, a tangle of wild growth along a roadside is more attractive than rows of planted trees, but in these days of rapidly moving vehicles, this scheme for roadside adornment is impracticable especially on narrow and winding highways. Even our beautiful back woods roads are now frequented by automobilists, and the public is beginning to demand legislation to provide for clearing the roadside of brush, for the safety of travelers.

The application of silviculture to our roadside problems, will we believe prove a happy compromise between those who would have nature take its course and those who would have the right of way cleared of woody vegetation. The informal grouping of trees which will result from the practice of these principles will greatly improve the landscape along our country roads where repeated "brushing out" too often leaves the roadsides ragged and unattractive.

4 Joy St., Boston, Mass. H. A. R.

April, 1918

MANAGEMENT OF THE HARVARD FOREST
1909–1919

OBJECTS OF MANAGEMENT

For ten years the Harvard Forest has been under management by the University with three objects in view:

1. A Model Forest to Demonstrate the Practice of Forestry

Up to now the methods, both business and scientific, involved in growing and in maintaining forest crops have been but scantily developed in this country. To see an organized forest where the various stages of growth are properly represented, where all the slow processes of silviculture are in successful operation, and where a regular yield in lumber is available without depletion of the forest capital, it was necessary to go to the Old World. Today the Harvard Forest, by a fortunate combination of its history, location, and management is very close to that unique condition.

2. An Experiment Station for Research in Forestry

In spite of the imminence of a national timber shortage and the economic ills that will accompany it, most of the technical knowledge required to handle forest crops is still lacking. For the region it represents the Harvard Forest is helping to supply that lack. It has practicable methods of reproducing and improving forests in operation; it has large plantations under test for varying situations; it has made and is making investigations of special problems connected with the growth, yield, and habits of species, the control of injurious insects, the repression of forest weeds, the measurement of logs, trees, timber land, etc. The bibliography of published results of such work will be found on page 22.

3. A Field Laboratory for Students

A forest is as essential for the training of a forester as a hospital for that of a doctor, and the longer a forest has been under management the more instructive it is to the professional student. With all operations on the Forest, both investigative and routine, annually recorded, it is possible for a qualified man in a short time to get a degree of practical knowledge or technical expertness which only an organized forest can furnish.

LOCATION AND AREA

Acquired by gift to the University in 1907, the Forest was first taken in hand in the autumn of 1908. It is located in the town of Petersham in northern Worcester County, Massachusetts. The nearest railroad connections are Athol on the north and Barre on the south, each being about ten miles from the general center of the property, that is the village of Petersham. The Forest lies in three separate tracts designated at the time of the gift as the Slab City Tract, the Meadow Water Tract, and the Prospect Hill Tract, and containing respectively 500, 793, and 775 acres. Of the total area of 2068 acres, 1775 acres are forested. The balance, nearly 300 acres, is accounted for by ponds, swamps, and grass land.

TOPOGRAPHY AND SOIL

The general topography and geological history of the region have brought about somewhat peculiar conditions of soil. As a whole, this part of the state is a plateau or pene-plain made up of a series of rather flattened ridges trending north and south. It is part of the general central upland extending from southern New Hampshire south to northern Connecticut. In the main the underlying formation is granitic, and on the ridges outcrops are frequent. The relative elevations are between 1100 feet, which is the general level of the ridge

tops, and 700 or 800 feet, which is the altitude of the intervening valleys. The highest elevation on the Forest, Prospect Hill, is 1400 feet above sea level. The bulk of the drainage is to the south, including the head-waters of the east fork of the Swift River. The whole land surface has been extremely flattened and degraded by glaciation. The result of this topography, formation, and geologic influence has been the formation of soils very stony in composition but on the whole heavy, and tending more to clays and loams than to sands, the only examples of which are to be found in small sand plains or gravel deposits near the base of slopes, or along streams in the main valleys.

There is a contrast in soil conditions between the uplands and the lower slopes or valley bottoms which is apparently the direct result of ice action. As is usual the deepest and richest soils are in the valleys and on the lower slopes. But the presence of extensive accumulations of glacial boulders has made many of these sites impossible for agriculture. It was probably in consequence of this fact even more than for protection against Indians that the early settlements developed mainly in belts on the broad ridge tops from which ice action had removed the worst of the boulders. There is thus the anomalous condition of large areas of soil agricultural in quality, but as land fit only for forest growth.

COMPOSITION AND HISTORY OF FORESTS

The distribution and past treatment of the forests of this upland have exercised a considerable control on the possibilities of management today. With regard to the occurrence of species, this northern portion of Massachusetts is a very interesting transition region. It is cold enough and sufficiently well watered to favor a number of the most important commercial species of the North woods. On the other hand, it is near enough the central hardwood region to contain a considerable number of trees which are more characteristic of southern Connecticut and the Middle States. Thus, of northern species the Forest contains red spruce, black spruce, beech, basswood, sugar maple, yellow birch, paper birch, red pine and even occasional balsams. Of species characteristic of the central states there are white oak, hickory, both pig nut and shagbark, black oak, scarlet oak, red maple, black birch, tupelo, sassafras and pitch pine. The chief species, however, are those which reach or approximate their optimum development in central New England, *i. e.*, white pine, chestnut, red oak, white ash, black cherry, and hemlock.

When the country was first settled the composition of the forest was very different from what it is today. From small fragments of the original forest which still exist, and from scattered documentary evidence, it is clear that the primeval condition was almost everywhere a mixed and many aged stand, containing both hardwoods and softwoods. White pine and hemlock made up the bulk of the softwoods, the pine occurring as a very tall and scattering overwood under which grew in great variety of size and age, hemlock, white ash, red oak, and the other hardwoods. This original forest, covering probably ninety per cent of the land area, tended to become pure hardwood on the deeper, moister soils and to merge into almost pure softwood on the upper slopes or drier, sandy situations. When the first settlers came there was probably very little pure pine in the locality.

The economic history of central New England has completely altered this natural composition of the forest. Most of the townships were incorporated between 1710 and 1740. The town of Petersham was settled in 1720. At the end of the first century, about 1830, the forest had been cleared to the point where approximately sixty per cent of the total land was in farms or pasture. Those cleared areas extended east and west from the ridge tops, so that the bulk of the forest standing at that date was on the lower slopes and along the margins of the valleys. During the ensuing forty years a number of important changes took place in the economic

status of the region. Manufacturing began to develop along the main streams. The Fitchburg and Boston and Albany Railroads were built. About 1850 the West began to be opened up. Then came the Civil War and the culmination of a decline in population which exceeded fifty per cent. The result was that in most upland towns an enormous area of cleared land was progressively abandoned, and these abandoned lands have been steadily reforesting themselves by natural causes. Owing to the reproductive habits of the various species, the reforestation has resulted in a number of temporary types which are in great contrast to the original forest. Large areas of mowing and pasture have come up to pure white pine and have produced the so-called woodlots which today make up the bulk of the commercial timber of the region. Other areas, even more extensive, where pine seed was not promptly available have produced stands consisting almost entirely of weed trees, such as grey birch, poplar, pin cherry and red maple, inferior in value and defective as to form and size. Very often there is some white pine in this type, but most of it is killed out in the first twenty years. Cut-over forest land, whether original forest or second growth and whether predominantly pine or hardwood, has steadily reverted to a larger and larger per cent of broad-leaved species. Thus, when the Harvard Forest was first put under management the outstanding silvical facts were as follows:

1. Except for a few fragments of original forest the stand was entirely second growth and under seventy years of age.

2. It was at least ninety-five per cent even-aged, having originated on cleared or cut-over land.

3. It was nearly everywhere of what are called temporary types, *i. e.*, mixtures of species not truly characteristic of the soil and other factors of locality. Even the pure pine is only a temporary type as is indicated by the fact that practically every pure pine stand fifty years or more old, is full of hardwood advanced growth. Furthermore, all the inferior species are now occupying much greater areas than in the original forest where competition was unrestricted.

4. A strong tendency was at work toward reversion to hardwood types.

MARKETS AND UTILIZATION

MARKETS and the possibilities of utilization chiefly limit the intensiveness of forest management. The markets existing in and about the Harvard Forest, which were good at the outset, have now reached the point of absorbing everything that is produced, except some of the limbwood. There are now no species and practically no size either of hardwood or softwood which cannot be marketed either at a profit or at least without loss. The adjacent town of Athol, to which there is a macadam road, contains a large variety of wood working concerns, and in Gardner is one of the largest collections of chair factories in the world. Among them these plants use nearly all the species of wood occurring in the region. In addition to the factory market, the town of Petersham itself furnishes a good demand for firewood and for a considerable amount of rough building material such as can be cut out of chestnut and hemlock. In the first few years of management it was unprofitable to sell red maple as lumber. Today red maple in reasonable widths brings thirty dollars per thousand. The result of such a varied and convenient market has been that the greatest difficulty in handling forest crops is largely eliminated, namely, the presence of species that cannot be sold.

GROWING STOCK, ROTATION AND YIELD

THE preliminary examination of the growing stock in 1908 indicated that, with the favorable markets at hand, it would be possible to manage the Forest on the basis of a sustained annual yield. Owing chiefly to the history of the land, there was a fairly uniform distribution of age from areas of young growth up to those of mature timber, an approach to the con-

stitution of a normal forest. The three tracts were carefully mapped, and with the maps as a basis the different forest types were tabulated according to age and area. A timber estimate showed a total merchantable stand of 10,500,000 board feet, of which about 10,000,000 was white pine. The ascertainment of the annual yield, or total amount of saw timber to be cut annually from the Forest, was based upon consideration of area, age, and volume. In the beginning only those stands were reckoned with which contained by volume fifty per cent or more of white pine, since hardwood was then comparatively unprofitable and yield tables applying to it were not available. The rotation and the mean annual increment for the area thus defined were determined from the yield table published by the New Hampshire Forest Commission in 1906. Since quality increment in most of the pine type is unimportant, the rotation for the bulk of the Forest was fixed at sixty years, which is old enough for a stand to bear seed, and not far from the point where the mean annual growth in volume culminates.

Being almost wholly second growth, the Forest was everywhere classifiable into blocks of uniform age. The growing stock was therefore summarized by area in three periods of twenty years each, covering together the duration of the rotation. The mean annual increment as derived from the yield table was found to be approximately 250,000 board feet. From the summary according to age and area it was possible to determine in which periods of the rotation, as compared with a normal representation of age classes, the growing stock was deficient and by how much, and to plan operations so as to bring about the necessary correction. Considering the total volume of the stand, and the surplus of volume in the third period, the theoretical allowable annual cut would have been about 335,000 board feet. On account of the lack of tried silvicultural methods, and the need of a reserve of sizeable timber for future scientific purposes, it was decided to put the annual cut at the conservative figure of 250,000 board feet, or the annual increment of the pine bearing lands of the Forest. The succeeding cuttings of mature timber have been kept for ten years at this figure, and a total of 2,500,000 board feet of lumber have been marketed.

A reassessment of the growing stock and increment was undertaken in 1919. In the interim practically all cut-over areas have been successfully reproduced. The absolute area of productive land has been raised by 150 acres through planting and release cuttings. An exchange of land has reduced the area of the third period and increased that of the second, and finally, a considerable amount of stumpage not reckoned in the first estimate has grown to merchantable size. Details of the improvement in volume, growth, and distribution of age are given in the tables (pp. 23–26). The significant facts are that the total volume of the growing stock is now 12,435,000 board feet, and of the annual increment, exclusive of cordwood, 380,000 board feet.

SILVICULTURAL METHODS

Reproduction Cuttings. In 1909 when the first cuttings were made on the Forest there were no tried methods of silviculture known or available. Furthermore, as experience proved, it was not even possible at the outset to make final choice of the species to be favored in the management. It was necessary, therefore, to proceed slowly in finding out how best to cut and operate the Forest so as to get the most successful reproduction. So far, with a very few exceptions, the annual cuts of mature timber have been confined to the pine type, which constituted at least eighty per cent of the merchantable volume of the growing stock and which up to a few years ago was far more readily marketable than hardwood. A number of the standard systems of silviculture as practised in Europe have been tried experimentally. Cuttings have been made according to the shelterwood method, with various modifications, the strip method, the group method,

and the selection method. The results of these cuttings have shown that it is possible to bring about reproduction by almost any system of gradual removal, that is a shelterwood or group method or any modification of them. Group and group selection systems, however, have serious practical drawbacks. They are costly to manage; they involve too much and too complicated logging on the same areas; the left-over portions of the stand are subject to windfall and are considerably in the way of the new growth, which becomes typically irregular and wasteful of growing space. The method which has come to be adopted and which is used on the Forest for reproduction of the pine type consists of a highly simplified stand method or shelterwood system, involving the removal of the crop in two cuts, the first a thinning, the second a clear cutting.

The pine does not reproduce itself at all under its own shade. Pine seed years occur not oftener than every third year, sometimes less often, so that even if a clear cutting of the forest immediately after the fall of seed results in good reproduction, there will still be two years out of every three when the operator will be unable to cut and at the same time secure the necessary reforestation. To get over this difficulty, a thinning is made within a few years of the end of the rotation, which removes about a fifth of the volume and results in a dense reproduction on the forest floor. Once this is established, usually in three to five years, the remainder of the stand is cut clear. These clear cuttings form the basis and bulk of each year's operation. In other words, every year a certain area which has previously been thinned is cut clean and yields seventy-five to eighty-five per cent of the total annual cut. Other areas, if possible adjacent, are thinned at the same time so that there is each year a sizeable operation that can be handled at the minimum of cost and which carries with it the preparatory work for subsequent clear cuttings.

The result of this method is a new crop of pine seedlings ranging from 3000 to 25,000 per acre. If the soil were true pine land, comparable to the sand and gravels of northern Minnesota or parts of Maine, the process would end there, with the new stand established and certain to develop to maturity. But, as noted above, in all pine stands large enough to cut there is present an abundant advance growth of hardwood saplings and seedlings in which white ash, red oak, chestnut, black cherry, and red maple are the chief species. Left to itself, this hardwood will crowd out the pine during the first ten years, as can be observed on the ordinary cut-over lands of the region. However, as a prospective crop, hardwood has undergone a very favorable change and the prices for the better species have so improved as considerably to exceed the average price for pine. In consequence, then, both of the persistence and vigor of the hardwood on the local forest soils and of the financial promise of such a crop, it has now come to be the settled silvicultural policy to reproduce the pine type with a stand of mixed pine and hardwood. The main feature of the problem is the handling of the young wood so as to get the utmost percentage of pine in the mixture and at the same time to take full advantage of the best of the hardwood reproduction.

The essential part of the treatment is the early weeding or cleaning of the young stand, but two preparatory measures have proved essential, both applied during the removal of the old stand. The first is complete slash burning, both for the sake of fire protection and to leave the young growth free. The slash is burned in small piles, usually as the logging proceeds. The second measure consists in cutting all hardwood advance growth close to the ground and in advance of the logging. The purpose of this is to secure an even, uniform start of seedling sprouts on the cleared area, to relieve the pine of competition for at least two years, and to preclude the development of irregular and bushy trees in the new stand. The first weeding is applied in the fourth year after cutting, by which time it is possible to make intelligent choice among the various elements in the stand and to iden-

tify the silvical and site factors which are likely to govern composition. For the most part, pine is favored on the drier sites or where the hardwood is scattering. Hardwood is favored on the richer soils or where established in particularly dense groups. Only by constantly changing the treatment as these conditions alter can the the best results be achieved. The hardwoods favored in the weeding are, in order of importance, white ash, red oak, sugar maple, basswood, cherry, paper birch, and yellow birch. Two weedings usually suffice to establish a valuable mixture which is prospectively free from inferior species and undesirable sprouts. The final result has cost from six to ten dollars per acre. If the work is undertaken at the proper stages in the development of the young stand a man can cover from one and a half to two and a half acres per day. Measured by the superior quality and value of the prospective yield, the cost is amply justified as investment in the forest capital. From the point of view of silviculture, being based solidly on the factors of site and the silvical tendencies of the Forest, this treatment is unavoidable.

In addition to final cuttings in the pine type, about 10 acres of mature mixed hardwood have been cut over. In this type as in the pine, there was present a plentiful advance growth of good hardwood. This, except for the absence of pine, has been weeded in the same manner. Exclusive of scattered damage cuttings, 65 acres of mature timber have been harvested. Ninety per cent of this area is satisfactorily reforested to pine and valuable hardwoods in varying percentages.

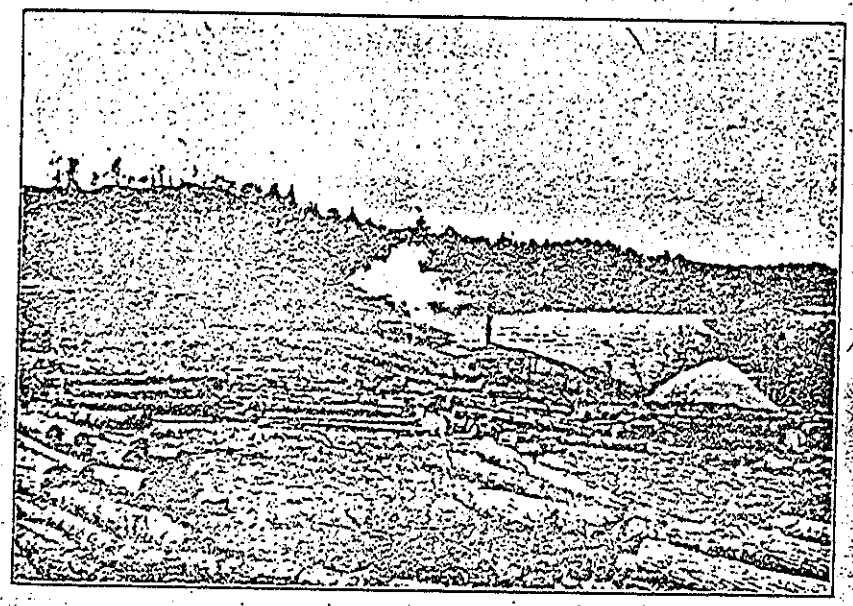
Improvement and Release Cuttings. Second only in importance to the maintenance of reproduction is the conversion of existing immature stands from a worthless to a valuable composition. In most natural second growth forests, particularly types which have originated on old fields, there are inferior species and malformed or over-developed trees, which gradually injure or suppress the better elements in the stand. This condition is especially characteristic of the pine and grey birch type. Release and improvement cuttings applied not later than the twentieth year will often convert such stands from prospective cordwood to the promise of a fair yield of saw timber. To date, upwards of one hundred acres of worthless mixed growth have been thus improved and added to productive growing stock.

Nursery and Plantations. For the reforesting of blank areas, to supplement natural reproduction, and for experimental purposes the Forest maintains a nursery. In addition to the strictly forested area there was in the beginning approximately 200 acres of blank land consisting chiefly of abandoned pasture or old field. These areas are being gradually restocked by plantation, mainly with white pine, but also with red pine, Norway spruce, Scotch pine, and European larch. Table III (p. 27) gives the chronological list of plantations and indicates their location on the index map.

LOGGING, MILLING, AND SUPERINTENDENCE

The Forest conducts every phase of the lumber and cordwood operations from the stump to the market. A resident superintendent and three men form the permanent crew, which is expanded at different seasons as the work requires. Equipment consists of a heavy woods team, a motor truck, a light car, and the necessary sleds, wagons, and woods tools. On each tract are several permanent mill yards with space for stacking and drying lumber and convenient to water supply. To one of these yards the annual cut of logs is yarded during the autumn and winter. About fifteen miles of wood roads connect with the yards and the public highways. In the spring a portable saw mill is hired to saw the logs at a price per thousand feet. Except for the sawing and occasional cordwood cutting there is no piece work on the Forest, and the cost of the various woods operations has compared favor-

ably with that of contract jobs. Moreover, in the all important matters of intelligent silvicultural treatment, the saving of valuable growth, close utilization, etc., the interest and knowledge that come with permanent employment are indispensable. Yarding to a central mill site makes the logging



SAWMILL AND MILL YARD

more costly than where the mill is set, as is usual, directly on the area to be cut; but on a forest under continuous management the argument is all in favor of the former plan. A mill set with its sawdust pile, sticking ground, etc., means the temporary sterilization of three to five acres of land, and the consequent destruction of reproduction. Furthermore, the concentration of logs and lumber attracts swarms of the pales weevil and the extra fire risk is considerable. With permanent mill yards these drawbacks are obviated, and it is easier and cheaper to pile and dry lumber properly and to deliver it to market.

COSTS AND RETURNS

PERHAPS the chief interest in the operation of the Forest is the determination of the financial practicability of forestry under the conditions obtaining in the surrounding region. To that end a cost accounting system covering all important items of the business is regularly maintained. Both costs of operation and prices have changed from year to year; on the average both have doubled since 1909; but the possible net return on the harvest of a given lot of lumber has not greatly altered and is still more dependent on the character of the management than on the changes in industrial and market conditions. Thus the following analysis of cost and return, although it represents but a single year, is relatively accurate for the period from 1909 to 1919.

TABLE I.

STATEMENT OF COSTS AND RETURNS AS OF 1919

		Cost per M.
I. DIRECT CHARGES.		
(a) Operating Costs.		
Logging, sawing, delivering, etc.		$15.00
Supervision		1.00
Interest on working capital at 4½ per cent.		.50
Insurance on lumber and equipment		.50
Taxes on lumber and equipment (assumed)		.40
Taxes on standing timber (assumed)		2.40
Interest on cost of land and timber at 4½ per cent.		9.00
Maintenance of property and equipment		.20
(b) Maintenance of Forest Capital.		
Reproduction	$75.00	1.00
Slash disposal	75.00	
Supervision	100.00	
II. INDIRECT CHARGES.		
(a) Increase of Producing Area.		
Planting vacant land	$50.00	.70
Improvement cutting	25.00	
Supervision	100.00	
(b) Permanent Improvements.		
Roads, Bridges, Yards, etc.		.20
TOTAL CHARGES		$31.80
AVERAGE PRICE OF LUMBER SOLD		35.00
NET PROFIT		$3.20

With exceptions presently to be discussed, these items represent actual outlay for work conducted on a scale and in a manner fairly to be called efficient. They can, therefore, be taken as criteria of what a strictly commercial organization could duplicate. The figure for net profit will of course vary under different types of ownership, financing, and management. The general operating expenses, for example, included under direct charges, might well be reduced under a larger unit of forest; in other words, the personnel and equipment could handle the work on about three times as much area. On the other hand, for a commercial owner under present laws the tax item would be from one to two dollars more than is here reckoned. The Harvard Forest being devoted exclusively to educational and scientific purposes, pays no taxes, and the figure classed here under that head represents an annual gift of seven hundred dollars to the town for the maintenance of roads. In respect to the rate of interest, private ownership might be compelled to reckon at six per cent which, with the tax rate, would nearly wipe out the margin of profit, unless offset by a reduction in operating cost and overhead. In the present case, however, it must not be lost sight of that the Forest operations under the head of "Increase of Producing Area," are paid for out of income, but as effecting large improvements in the value and yield of the property, they might be charged to the capital account. It may be said that the Harvard Forest, both as to market, growing stock, and productiveness is peculiarly adapted for practicable handling on a sustained yield. For many ownerships, the elements of fire risk and taxation, together with the smallness of the margin of profit, are still strong deterrents to the business of forestry. The Harvard Forest has shown, however, that even if the necessary maximum be spent upon these items lumber can be grown continuously on an organized forest for the prevailing market price.

PROTECTION

THE expense of fire protection on the Forest is extremely low. To begin with the risk is slight. The topography and the character of the forest types makes it difficult in ordinary seasons for fire to run more than a short distance. The frequent swamps and hardwood flats as well as the network of roads tend both to restrict the spread and to facilitate the control of possible fires. In ten years there have been four fires on the property, which have covered a total of about twelve acres, with an estimated damage of not more than seventy-five dollars. Few fires are started, notwithstanding a very considerable resort to the Forest by the public. The nearest railroad is six miles away, and in general persons using the woods are careful about fire.

The general state organization for protection extends to the town, which has a chief fire warden and five deputies, a very complete telephone system, and a motor truck with fire fighting equipment. Fires not promptly observed locally may also be reported to the warden by the lookout on Mount Wachusett. In view of these favorable conditions the Forest, except for a small equipment of extinguishers, makes no direct outlay for protection other than that of slash disposal in the woods.

This measure, indispensable to the practice of intensive silviculture, is no less necessary on the score of protection. Experience has shown that if pine tops are disposed of even a fire in mixed young sapling growth may be stopped. Whereas, if the slash is not burned a fire under such conditions cannot be controlled. The slash from hardwood timber, especially where the tops can be put into cordwood, is not a serious barrier to reproduction and can usually be left without great risk of fire. The disposal of softwood slash is a job which can be greatly cheapened and facilitated by skill and experience. Under some conditions "live burning" as the logging proceeds has proved to be the easiest and cheapest.

This means having a number of small fires going as the logs are being cut so that the limbs require to be handled only once. Such a method is especially effective where limbwood can be utilized; and it results in appreciably cheapening (10 to 20 cents per thousand) the skidding and hauling of the logs. Often, however, bad weather or extra heavy tops that cannot be utilized make this inexpedient; or it may be best to drop all slash burning and concentrate on cutting and hauling so as to take advantage of good sledding. No uniform system can be laid down in advance because, even assuming judgment and experience in the woods crew, there are too many variables to reckon with — weather, economy in the operation as a whole, marketability of limbwood, stand per acre, and above all, the size and form of the tree crowns, which may vary from fifteen to fifty feet long in timber of the same age but different density and composition. Not considering the occasional incidental economy brought about in logging, the range of costs for slash disposal alone is shown in the following table.

TABLE II. COSTS OF BURNING PINE SLASH

Forest Type	Method Cutting	Cut per Acre Bd. Ft.	Crown Forms	Cost per M.	Rate Wages
White Pine	Thinning, 5 acres	10,000	Short, light	$ .15[1]	$2.00
" "	Clear cut, 4 acres	45,000	Short	.30[2]	2.00
" "	Groups, ⅛–½ acre	15,000	Long, heavy	.65[2]	2.50
" "	Clear cut, 9 acres	30,000	Short	.70[3]	4.00

[1] Limbwood 3" and over cut for cordwood.
[2] No limbwood cut.
[3] Limbwood 3" and over cut on 3 acres.

THE HARVARD FOREST AS A DEMONSTRATION TRACT.

By R. T. Fisher, Director of the Harvard Forest.

The Harvard Forest has belonged to the University for twenty-three years. In 1908 it represented merely what a hundred and fifty years of ups and downs in rural colonization had done to the virgin wilderness. In 1931 it represents what twenty-three years of intensive management have done to organize and improve the natural forest. In the long perspectives of forestry this period is trifling; but in a country where the average citizen has so recently exchanged the family axe for a niblick, it is sufficient to make the Harvard Forest the oldest institution of its kind in America and perhaps to make pertinent the query as to how it has functioned as a means of education.

In the use of the property by the Forestry Department of the University, there have been three objectives: a model forest to demonstrate the practice of forestry; a laboratory for the training of professional students; and an experiment station for research. But although the Forest has provided a field for countless exercises by students and the material for many bulletins and papers, it is not these but the forest itself which has translated the developing technique of management into realizable and convincing terms. It speaks in the only language which can be understood both by the wise and the simple—visible results.

The forest consists of 2,100 acres of varied woodland situated in the town of Petersham, in northern Worcester

In view of the interest which is being aroused in the subject of demonstration forests in England it is thought that this article which has been written by Professor Fisher, of Harvard University, is particularly opportune.—Ed.

County, Massachusetts, where from earliest times wood-working industries have been an important item in the livelihood of the people. Well timbered almost all over, it contains a greater variety of the different stages of forest represented in New England history than can be found on an equal area anywhere else in the region. Besides authentic fragments of the original primeval stands, it has phases of second growth and forest types characteristic both of the northern and of the central forests.

Conditions at the outset were peculiarly favourable not only to significant developments in silviculture but even more to the creation of a successful business enterprise in forestry. There being already on hand in the existing growing stock a merchantable volume of ten million board feet (1,430,000 cu. ft.), it was possible to meet the stipulation of the governing board of the University that the forest must be self-supporting. This condition, as can readily be seen, has been a powerful influence for economy and efficiency in management. In the matter of markets, nearby industries have furnished an outlet for almost every species on the property, and there has been also a fair demand for fuel wood. By a happy accident of history and previous ownership there was also a fair distribution of age groups so that it was possible from the beginning to set up a working plan on the basis of a sustained yield. The forest has had its own sawmill, a couple of motor trucks for hauling and delivery, and a small year-around crew of woods workers under a resident superintendent. Aside from special projects of research, both biological and economic, the management has been directed toward the improvement of the growing stock in volume, increment, and age distribution, and the evolution of effective silvicultural methods for reproduction and the maintenance of growth and quality.

The progress in these directions has been tangibly reflected in the forest itself. In twenty-three years five million board feet (710,000 cu. ft.) have been harvested from the forest; yet in consequence of the maturing of younger stands and the increasing increment of the period, the present merchantable volume is approximately twelve million (1,710,000 cu. ft.). The annual increment, originally estimated at

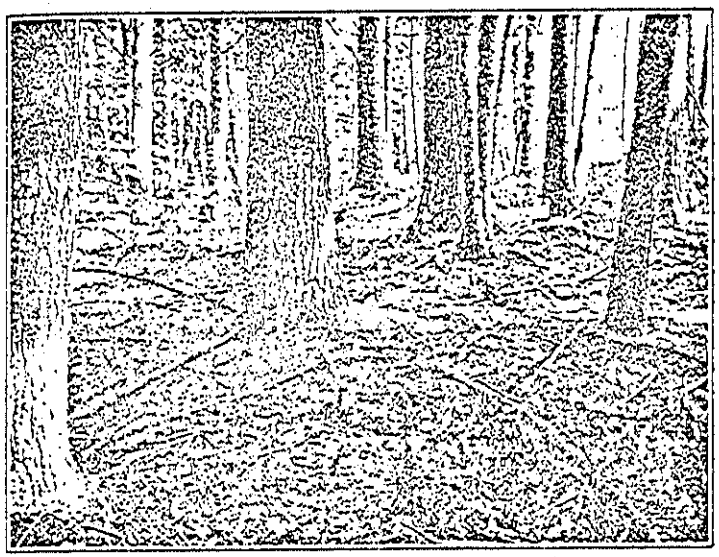


Fig. 1. Old Field White Pine (control area) eighty years old. Decomposition in the humus layers is slow and there is a tendency to podsolization in the soil. This is an uncut portion of the stand which preceded the hardwood shown in Fig. 2.

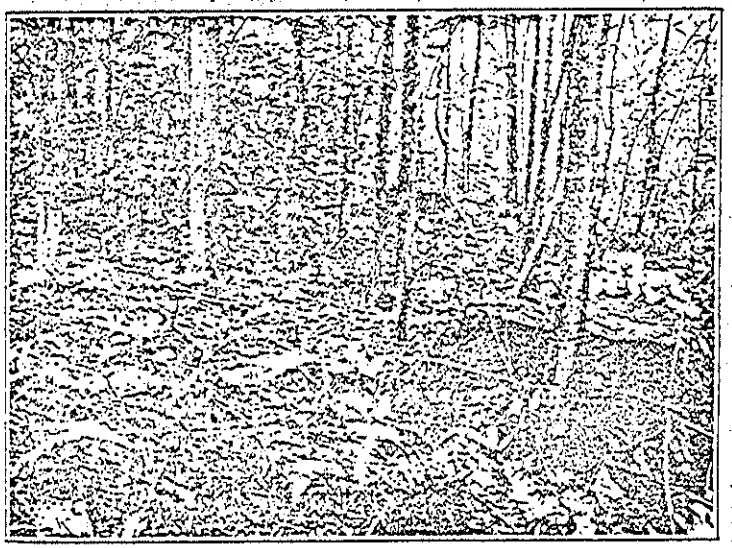


Fig. 2. Sapling stand of White Ash, Red Oak, Yellow Birch, etc., eighteen years old. Result of weeding advance growth which originated under the pine (note stumps). Here organic decomposition has been rapid, and the soil has changed to a mull type of active fertility.

Fig. 3. Virgin stand of Hemlock, Yellow Birch, Beech, and Sugar Maple.

Fig. 4. Selection cutting in stand of Mixed White Pine and Hemlock.

two hundred and fifty thousand board feet (36,000 cu. ft.) is now about four hundred thousand (60,000 cu. ft.), and the uniform distribution of age classes required for continuous production has been substantially approached. There has been a net income, available for improvements and equipment, of $1,000 to $2,000 a year equivalent to 50 cents to $1 per acre.

Under the existing scheme of management it has been necessary to control the business and economic phases of operation as carefully as the silvicultural. In the system of records and accounts which has been developed, both these phases of work are dealt with. All labour costs, operating expenses, and the various forms of overhead, including interest on the capital invested, are currently posted and periodically summarized. Form sheets are provided for annual statements according to block, compartment, and type of the amounts cut in timber and other products. The status of the growing stock as regards volume, composition, age, and growth is kept track of in a card file in which each card carries the data on a single uniform stand, a number of which may occur in a single compartment. Such a file, in which annual changes due to cutting or planting are currently recorded, makes it easy to summarize the general condition of the growing stock at any time. In the matter of the silvicultural and biological aspects of the management, the records are even more comprehensive. In addition to the stand cards, notes and observations upon the cutting or experimental areas are filed by compartments. Permanent sample plots and other areas set apart for special studies are given an additional form of record. Finally, and applying to all forms of forest operation, there is a photographic file for preserving serial views of the same spot and a full set of large scale compartment maps on which all significant changes in the forest are plotted.

The task of maintaining such a system of records is difficult, and quite naturally becomes more so as the areas under treatment or experiment increase. Nevertheless, experience has proved that the forest is valuable as a demonstration almost exactly in proportion to the completeness and accuracy of its records. As time goes on new

and unforeseen problems arise for solution. With a forest whose history is accurately known in both economic and silvical terms, it is often possible to make a significant study which would have been impossible on unmanaged areas. Thus, adequate records may furnish in the end not only what they were originally planned for, but quite unexpected by-products of knowledge.

Through its continuing experience as a demonstration area the forest has been able to establish certain concepts of silvicultural policy which have influenced not only the point of view of professional foresters, but also the public propaganda which takes its cue from that source. For the past thirty years, which is about the life-time of the profession in America, various public and semi-public agencies in the north-east—federal and state forestry departments and private associations—have built up an immense campaign designed to educate the landowners to the production of timber. From the beginning this took the form of advocating coniferous plantations, generally white pine; and so thoroughly has this policy been advertised that forestry in the public mind of New England has been generally thought to begin and end with re-forestation by planting. In consequence, after thirty years we have some hundred thousand acres of pine plantations so poor in quality that few of them will ever repay their cost.

By a curious irony of economic history there were several apparently good reasons for emphasizing the planting of pine. It was about 1900 that the extraordinary accidental production of enormous volumes of white pine on the farms and pasture lands abandoned in the middle of the last century began to be widely used in a great many local industries, particularly for the manufacture of wooden boxes. Originating on areas especially adapted to white pine reproduction, and at a time when in the existing remnants of original forest, seed trees of inferior species were relatively scarce, these so-called pine woodlots, generally in pure stands, showed remarkable productiveness. At the usual cutting age of from fifty to sixty years, volumes per acre ranged from twenty to fifty thousand board feet (three to seven thousand cubic feet), which in the prosperous pre-

Harvard Forest as a Demonstration Tract

war days of the woodworking industries meant a stumpage value of from $300 to $500 an acre. How much this purely gratuitous reward of nature for the failures of man has meant to the struggling farms of upland New England may be gathered from the fact that between 1895 and 1925, fifteen billion board feet (over two billion cubic feet) of second growth pine have been cut in central New England, with a manufactured value of over $400,000,000, more than half of which has gone to the owners of the land and the local population which took part in the logging and milling. If one considers also how simple and understandable to the layman is the planting of trees as compared to the handling of established forests, it can be seen that there were obvious reasons for believing that pine plantations were a good thing to advocate. Unfortunately the use and value of old field pine have seriously declined, and the stands of recent origin are inferior in quality.

On the Harvard Forest almost at the outset of management it was decided not to attempt to maintain the pure pine type but rather to convert it into mixtures, either hardwoods alone or hardwoods with pine. This decision was based in part on the theoretical value of mixed stands, and in part on the belief that the old field pine was a transition type, not in the long run so suitable for the soils and climate as certain simplified forms of the original mixed types of the virgin forest. Subsequent observations made this policy seem additionally sound. The increment of the old field pine was observed to show an abrupt falling off from forty-five years on; natural pruning, especially in plantations, was notably slow, so that only low grade lumber could be produced; the abundant advance growth generally developing in the later life of the pinewood was always of hardwood species, often of the most valuable kinds, never of pine, which not only indicated a tendency to reversion but made a pine type unduly costly to maintain.

After eighteen years of converting pine stands to varying mixtures, there began to be observed a contrasting condition of soil profiles, which conclusively showed why, for the region and forests under consideration, the mixed stand was the better objective (see figs. 1 and 2). Under the

pure pine cover decomposition in the humus layers became progressively slower, leaf litter in a more or less felted form accumulated to considerable depths, with the formation of but little true humus and accompanied by a gradual reduction in the depth and tilth of the top soil. This condition was apparently coincident with the falling off in growth. On the other hand, under the hardwood or mixed types which had followed the cutting of pine, the reverse of this process had set in promptly: a rapid decomposition both of the organic layers previously accumulated and also of the current fall of leaves, accompanied by improvement in the depth and tilth of the top soil or enriched horizon. In this case also there was immediate response in the growth of the trees. It was apparent, too, that the prospective quality of the timber, as indicated by straightness of stem and rapidity of pruning, was notably better than with the pure pine. The outcome of this experience, which could only be achieved on a forest deliberately and efficiently devoted to the continuing observation and recording of silvicultural experience, has been quickly disseminated into the general professional consciousness not only by the men who have taken their professional training at the forest but by large numbers of practising foresters who are continually visiting the tract.

Still another instance in which the Harvard Forest has been of service in defining a useful principle of regional forest management has been to demonstrate the economic and silvicultural possibilities of improved productiveness in natural stands. It has been a consequence of the propaganda for the planting of pine that little or no attention has been paid, even by forest owners who have undertaken planting, to the cut-over lands already forested by nature, which have been vaguely supposed to be "devastated." But the large natural regeneration in New England has been uncommonly abundant, notwithstanding the almost complete lack of any conscious measures on the part of timberland operators to secure it. But although some sort of tree crop usually follows the logging operation, a hundred and fifty years of cutting, clearing for farms, natural reafforestation of old fields followed by more cuttings and perhaps repeated fires, have profoundly altered the regional distribution

of species. What is locally known as the weed tree, that is, small short-lived species such as grey birch, poplar, pin cherry, etc., together with immense areas of degenerate coppice have probably increased in the last century at least a thousand per cent. This means that more valuable species such as white ash, red oak, white birch, and pine have been correspondingly reduced, not because they are generally absent in the young growth which follows logging, but because they are progressively suppressed by the faster growing weeds and coppice. Indeed this regional degeneration in composition has gone so far that the weed element and its correction constitute the first and greatest problem in New England silviculture. Twenty-three years of dealing with this difficulty on and about the Harvard Forest have shown proofs in the form of highly valuable stands, first, that there are very large areas of cut-over land which, if taken in time, can be converted through the process of weeding or cleaning from potential worthlessness to excellent stands, often in almost ideal mixture; and second, that the cost of this work per acre is generally far less than that of planting. This demonstration has very materially helped to influence the general realization that much of New England's twenty-five million acres of existing forest land has a realizable productiveness out of all proportion to the planting of new land.

The ways in which such lessons as these become available have multiplied through the years. Probably first in importance, if one considers the long view, would be the knowledge and grasp of fundamentals absorbed by the professional students who come to the forest for graduate training and research. Such men naturally transmit and apply their philosophy more and more widely as time goes on. The results of all research projects as well as maturing reports on various phases of silviculture and management are published from time to time as bulletins of the Forest or articles in technical journals. To a considerable extent also local newspapers publish stories about phases of work that may be useful to the general public. There has been maintained also at Petersham a sort of unofficial service bureau. Through the Forest staff there is offered free to residents of the town, and at cost to other land owners in the vicinity,

advice in forest management. This takes the form of estimates and valuation of timber, marking for cuttings, planting plans, etc. In many cases the actual work of logging and milling, planting, or weeding may be carried out for the owner by the woods crew of the Forest in combination with its own work. The Town Forest of Petersham is managed in this way. Through these kinds of direct service the Forest has contributed to the development, improvement, or re-forestation of nearly fifty thousand acres in the surrounding region.

Last of all, and perhaps most important, are the outward and visible effects of applied silviculture, which may be seen in the forest itself and which with the written and other records embodying results and progress are shown to large numbers of visitors, sometimes as many as two hundred and fifty to three hundred in a year. Most of these visitors are foresters from federal or state departments or from forestry schools. Many also are men interested in the biological sciences, and the remainder, a very considerable number, are forest owners or lumbermen. It is difficult to estimate the total effect of all these forms of contact between the Forest laboratory and the public and professional consciousness; but to one who has seen the process going on for over twenty years, it is obvious that there has been an ever widening diffusion of knowledge about the handling of forests which is coming to be reflected in the policies and methods of the region. It is not far from the truth to say that, for all around usefulness, no other means of education can equal a highly developed demonstration forest.

In the Harvard experience there has been more than a hint that forestry depends as much upon a state of mind as a state of markets. There has been little in the economic history of the United States to induce foresight or deliberate provision for the future. "America, the land of the free," has been more than a slogan of patriotism; it has been almost a promise of material plenty. There has been free timber—two-thirds of a continent covered with the most varied and valuable reservoir of wood that the world has known, and with no cost of production. There has been free land—first the allotments to settlers in the thirteen

colonies and then the immense disposals of public domain by the federal government. Along with free land went the implication of free use and access, not only on areas still publicly owned but also on private lands which still bore the aspect of wilderness. In some cases these traditions have acquired the force of rights, as in the early grazing on our public domain in the West and the policy established in all our states, that fish and game belong to the public and not to the owner of the land. In some regions, notably New England and the South, the idea that nature will provide has been still further strengthened by the immense replacement of usable second growth timber on abandoned farms, another free gift of raw material to a people already used to plenty.

A history like this has not conduced to the habit of taking thought, still less to any interest in, or comprehension of, the technical or economic processes of forestry. On the contrary it has given rise to some widespread fallacies that have helped prevent even such forms of forestry as existing economic conditions would have made profitable. There is the idea that investments in forests should yield a very high return, at least six per cent. There is the assumption, clearly reflected in the practice of New England town assessors, that only mature trees are timber and that sapling and seedling stages are worthless brush. There is the habit in the woods of cutting always the nearest and best trees, whether or not the poorer ones, whose removal would benefit the stand, are equally satisfactory. There is the conviction, still widely held among lumbermen, that since nature always has produced our timber, it is necessary only to control fires and nature will do it again. Finally, less clearly definable but no less definitely an obstacle to successful forestry, is the obliviousness of the general public to the productive values of forest land, an attitude which is responsible for most of our forest fires and for much damage to trees and plants.

In the face of such a general state of mind as this, the most favourable economic conditions might well be slow in stimulating forestry. On the other hand, it is clear that where there is a reasonable understanding of the technique

of silviculture, it is possible, even in the midst of destruction, to make a success of forestry. There are a number of ownerships in New England where the same land in the hands of a small wood-using industry has produced timber and a moderate income for several generations. These properties, like the Harvard Forest, have done their bit to spread the realization of how forests are actually managed and of how very far the proper knowledge and purpose will go toward making them profitable. In the words of Mr. Ward Shepard, who for several years has been helping to guide the public relations of the Forest Service, "The solution of the forest problem depends far more on intelligence, will, and good workmanship than on economic predestination."

What Is Thought of the Forest

The following comments from professional, scientific, and business men who have visited Petersham indicate the progress which the Forest has made toward fulfilling its objects of management.

From P. W. Barr, Chief of Research, British Columbia Forestry Branch, January 22, 1928:

> "As one who is interested primarily in the practice of forestry in the woods, may I assure you that your Forest offers much more in the way of instruction and inspiration than any place I have visited."

From the "Blister Rust News" of the Department of Agriculture, 1928:

> "Asked what he considered the most instructive example of forestry in America, Mr. von Maltzahn (of the Mecklenburg Forest Service) stated that he was most impressed by the Harvard Forest at Petersham, Mass., and that every German forester might be able to learn in this forest."

From W. B. Greeley, Chief Forester of the U. S. Forest Service, April 21, 1928:

> "The two days at Petersham last August stand out as red letter events for many reasons, among them that I felt closer on that occasion to native American silviculture than at any other time in my life."

From Charles H. Keith, President of the New England Box Company, Greenfield, Mass., June 27, 1924:

> "I can say so far as the New England Box Company is concerned that the research work which is being done (at the Harvard Forest) and which no individual can afford to do, is going to have a very important place in the reproduction of timber for New England. We are convinced of its practicability because it has made profits for us.
>
> "Professor Fisher is spending a good deal of time to improve the marketing of Forest Products and has demonstrated to us a possible saving of $30,000 a year in the lumber being used by us to make boxes. At the Harvard Forest they show you results and not theory. . . . They are making constant progress in converting lumbermen and manufacturers to the value of the quality of the service they render."

From D. E. Lauderburn, consultant for lumber and paper companies, 1929:

> "It is very fortunate for our profession that there is such an organization as the Harvard Forest. . . . Such studies . . . are very helpful to us who are in private and consulting work, trying to establish such silvicultural work as is financially possible, but without the training and opportunity for much silvicultural research."

From the "Nature Magazine" for July, 1927, an article, "Show Windows of Forestry" by Tom Gill:

> "The Harvard Forest at Petersham is a perfect forest laboratory, the most interesting in the United States."

From the "New England Homestead" for August 22, 1925, an editorial, "Farm Forestry Made Easy":

> "Experience in the Harvard Forest and the facts it has proven in field and laboratory give to the results actually achieved by Director Fisher and his co-workers a value that is as intensely practical as it is thoroughly scientific. Because of this truth, because the lessons learned here are just beginning to be applied by farmers and lumbermen throughout New England, and because these easy methods mean profits instead of loss from waste lands, a study of Harvard Forest results has been made by our President, Herbert Myrick, and will be featured in The Homestead through the coming winter in time to be of most seasonable interest—a series of stories and pictures of human interest and much practical value."

From the "Service Bulletin" of the U. S. Forest Service for May 4, 1925, an article, "The School of the Woods" by Ward Shepard, Assistant Chief of the Public Relations Branch of the U. S. Forest Service:

> "Every forester in the United States ought to visit the Harvard Forest to see the possibilities not merely of growing timber, but of forestry as a craft, an art, a satisfying pursuit."

From the "Yale Forest News"—the alumni journal of the Yale School of Forestry, which is the oldest and most influential professional school of its sort in the country—for April, 1926:

> "This record of continuity in intensive silvicultural practice is probably unequalled in America and it is to the cumulative results of this management that Fisher's contribution to forestry owes its great value.

"The Harvard Forest gives to the profession that which is most needed now and which will continue to be our most urgent requirement for decades to come—a demonstration area where the actual working out of forestry practice as a successful business venture can be studied at first hand without having to visit a foreign country to convince ourselves that it can be done. Fisher represents the new idea in America, which must supplant the old pioneer psychology of prodigal waste."

Why the Forest Needs Funds

Up to a few years ago the Forest had had no financial support other than the income from forest products and the tuition fees from research students, necessarily few in number. In the last five years the necessary expense of scientific work—maintenance of records, enlargements of equipment, upkeep of buildings, etc.—has reached an amount which the income from cuttings cannot and should not be expected to meet. On the contrary it is felt by a large number of the scientific and business friends of the Forest that some of the area should be withdrawn from the necessity of periodic cutting (with consequent reduction of income) because of its special and unique value either as illustrating conditions that are vanishing or because of the demonstration value of the results of certain treatment. Furthermore, the members of the staff are very inadequately paid and their continued service is largely due to the special professional value of connection with the Forest and to faith in its future. At present, although the Forest is producing as great a revenue as ever, there is an annual deficit, which has been met by annual gifts. If the fruits of twenty years of building are to be realized and secured for the future, the Forest must have a substantial increase in its resources for unrestricted application to the maintenance of the plant—both buildings and forest—and to the organization for research and record at Petersham.

What the Forest Needs and for What Purposes

The amount required to secure these objects is a minimum of $300,000. At least $275,000, should be an endowment for salaries, building maintenance, and to meet the general overhead of conducting unproductive and experimental work in the woods and releasing from cutting such areas as are most valuable for demonstration and scientific purposes. $25,000 is needed for necessary alterations and improvements in the headquarters building. The present building is ample in size, but a dangerous fire-trap and unsuitable in design. It needs a small fireproof wing for records, maps, etc., a central heating plant, new and safe wiring for electricity, a garage for the Forest cars, and a separate cottage for the superintendent, so that the wing now occupied by him may be used for other purposes. Mr. Bulfinch, of the firm of Coolidge, Shepley, Bulfinch & Abbott, estimates that these alterations will cost from $20,000 to $25,000.

Present Status

Income

Forest Production Research Fund, $100,000	$ 5,500.	
Bliss Fund, $60,000, salaries	1,500.	
scholarships	1,500.	
Tuition fees (average)	1,000.	
Sales of forest products	15,000.	
Rent of cottage and student rooms	600.	$25,100.

Expenditures

Forest operations	$10,000.	
Maintenance of buildings, equipment, unproductive experimental and woods labor and other overhead	6,000.	
Salaries:		
Director	3,000.	
Assistant director	3,000.	
Research associate	1,200.*	
Forest assistant	2,500.	
Expenses of research: supplies, equipment, transportation, etc.	1,500.	
Scholarships	1,500.	$28,700.

Deficit, $3,600.

Status with Required Endowment

Income

Forest Production Research Fund, $100,000	$ 5,000.**	
Bliss Fund, $60,000	3,000.	
New Endowment ($300,000 less $25,000 for building)	13,750.	
Tuition fees	1,000.	
Sales of forest products (reduced operations)	12,000.	
Rent of cottage and student rooms	600.	$35,350.

Expenditures

Forest operations	$10,000.	
General overhead: supplies, equipment, roads, bookkeeping, town gift in lieu of taxes, insurance, unproductive woods work, and general superintendence	6,000.	
Salaries	15,000.	
Director, Assistant director, Research associate, Forest assistant.		
Building maintenance	1,000.	
Scholarships	1,500.	
Research expenses: supplies, equipment, transportation, etc.	1,850.	$35,350.

* Toward this salary an equivalent sum is contributed by the U. S. Forest Service.

** Safe expectable rate of return.

NEW ENGLAND FORESTS: BIOLOGICAL FACTORS[1]

R. T. Fisher

The Original Climax Forest

WHEN settlements were first established on our coast, early in the seventeenth century, New England was almost entirely forested. The accompanying map indicates the general composition and the distribution of the tree species originally characteristic of the district. Broadly speaking, the occurrence of these regional units of forest is governed by the climate, physiography, and soils. Thus northern New England was in the main covered with spruce and fir and the so-called northern hardwoods: beech, yellow and white birch, and sugar maple. Southern New England was mainly dominated by a large variety of hardwood species more characteristic of the Middle States, in which a number of species of oak and hickory predominated. Between these two extremes was a large more or less transitional area, roughly described as "Central New England," where white pine and hemlock mingled in varying proportions both with species characteristic of the adjacent regions to the north and south, and with certain others, such as red oak and white ash, not originally so abundant in either. None of these regional units was sharply distinct, but each exhibited extensions due to the effect of elevation or of fundamental soil composition upon climate and moisture. Thus the northern forest extended well down into Berkshire and Hampshire counties into Massachusetts, along the higher elevations of the Berkshire Hills, and in a few elevated spots in Worcester County. Similarly the oak forests of southern New England came north for a considerable distance into the lowlands of southeastern Massachusetts and up the Connecticut River valley. Cape Cod, almost a climatic and geological unit by itself, bore a forest principally of pine and oak.

In size and outward appearance these so-called original forests were in marked contrast to most of the woods of today. In the main the stands were mixed, often containing a great variety of species of many sizes and ages. If we disregard extremes of situation—such as mountain summits, sand plains, or swamps—and consider only the preponderance of area where temperature and moisture were not subject to wide variations, the life history of these forests, whether in the north or south, was much the same. Over central New England, for example, one may picture a forest in which broad-leaved trees

[1] For notes see below, p. 222.

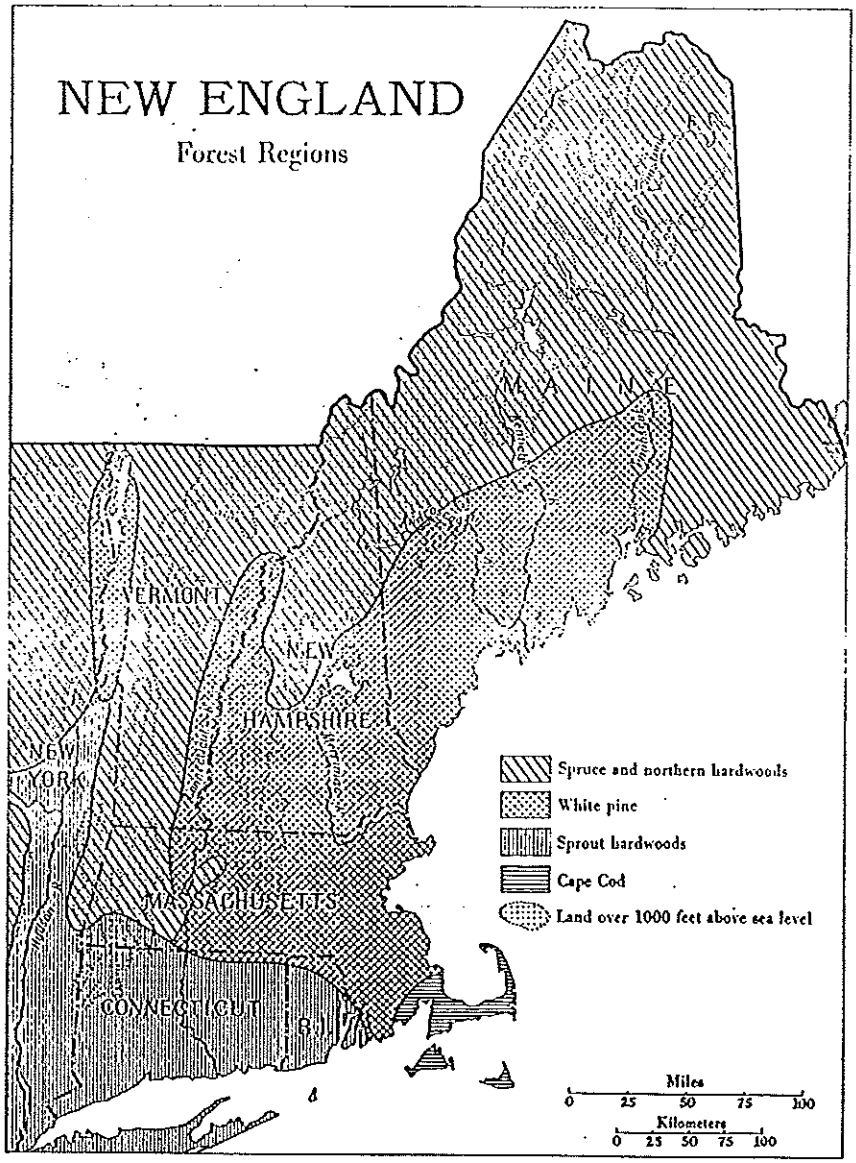


FIG. 1—Forest regions of New England. Based on map of forest regions of the northeastern United States, by P. W. Stickel, Northeastern Forest Experiment Station, Jan., 1927. Altitudes generalized from U. S. Geol. Survey's map of the United States, 1 : 2,500,000, 1914.

and hemlock formed a dense stand from eighty to one hundred feet high, above which, either by small groups or single trees and varying greatly in abundance, white pines reached a height of 150 feet or more. It is generally believed that such a forest was self-maintaining, in other words that the losses through old age or injury were recruited from younger and smaller trees gradually developing underneath, so

that over periods of centuries and on the average the representation of species remained about the same and the general size and appearance of the forest was unchanged. This condition of equilibrium is what is generally called a "climax forest." It means that if the stand is truly self-maintaining, all of the species represented are long-lived and more or less capable of reproducing and surviving for long periods under the heavy shade and prolonged suppression of the larger trees.

Changes in the Climax Forest

It is a popular if not a scientific idea that the primeval forest was almost as changeless as the hills. If the ordinary physical factors of temperature, rainfall, and the other manifestations of climate were regular in their operation and not complicated either by exceptional changes or by the influence of man, as on sheltered sites with deep soils, some forests might indeed remain unchanged for indefinite centuries. If, however, we study—as has recently been done[2]—the detailed records of life history in such original forests as still remain, we find evidence, even with no human factors in operation but the aboriginal Indian, that there must have been over long periods important changes in the distribution of species and the character of the forests within each of our climatic regions. Undoubtedly forest fires are more prevalent and destructive today than when the Pilgrims landed; but there is convincing evidence that everywhere fires were of periodic occurrence both from the practice of the Indians and occasionally from lightning. The principal difference between the aboriginal forest fires and those of today is that the earlier fires were probably less destructive in the larger woods and less prone to cover big tracts in a single burn. In addition to fires it is only necessary to consider longer stretches of time, such as centuries or more, to find unmistakable signs of other destructive agencies: windthrow, generally occurring on uplands or exposed ridges and often prostrating large areas of trees; lightning, which sometimes kills a dozen or fifteen trees with one bolt; ice storms, shattering many acres of tree tops; and, probably in the wake of these, fluctuating attacks from injurious forest insects or disease. It is likely, especially on drier and more exposed sites, that such periodic calamities as these, upsetting for a time and sometimes over large areas the equilibrium between local climate and soils and the natural requirements of tree species, were collectively the most powerful influence governing pre-Colonial forest history. Without the recurrence of fires we should not have had the heavy forests of pine in central New England reported in some localities by the early settlers. It is likely also that, without these periodic upsets providing breaks and exposures in the ancient forests, many of our short-lived, light-seeded species such as gray birch, pin cherry, and

aspen would have been even more rare and restricted in distribution than they actually were in the original forest. Thus, while areas of big timber certainly predominated in the early forests as traversed by the pioneers, there must also have occurred many areas where reversions to younger woods or shorter-lived species were in progress. As a background for the study and understanding of forest succession and growth, and for interpreting the many and varied forms of degeneration that have followed settlement and development, the original or climax forest is invaluable. It is unfortunate for scientific as well as economic reasons that today less than 5 per cent of existing forests date back to the settlement of New England.

To understand what has happened to the remaining 95 per cent of our original forest area, it is necessary to trace the progress of the use of land down to the present day.[3] In such a complicated development only the principal tendencies can be touched upon. As regards ultimate effect upon the forest, we may almost disregard the century from 1600 to 1700. This was in the main a period of pioneering. For the most part the settlements and clearings, at first mainly for agricultural purposes, were confined to coastal strips of a few leagues in width or to the bottom lands of important rivers, like the Connecticut. Aside from the initial clearing, such timber as was used and the little that was exported was culled at convenient distances from the sea or along the principal rivers. Furthermore, much of the land thus cut or cleared has continued to be devoted to agricultural, industrial, or residential uses and may be omitted from consideration of forest history in general. The bulk of the forest area, however, did not begin to be seriously altered until the early eighteenth century with the settlement and gradual development of the interior.

In the forest history of the last two hundred years we may distinguish two main types of land use: farming and lumbering. Although at the start and in the typical small community of the eighteenth century the two forms of use were combined, the lumber business as it became better organized spread into the wilder portions of Maine, New Hampshire, and Vermont, where farming was difficult or impossible. We may thus for simplicity consider southern New England, including roughly the area south of northern New Hampshire, central Maine, and northern Vermont, as a region primarily affected by agricultural settlement and the rest of the region, in general the wilder, colder, and more mountainous parts, as a district affected largely if not exclusively by lumbering. Each of these two main types of land use has had a profound effect upon the character and productiveness of the forests of today.

Forest History of the Farming District

In the farming district practically the entire area came to be covered by organized towns, most of them settled and incorporated

during the first half of the eighteenth century. A steadily increasing area was cleared for crops or grazing, and the remainder of the original forest was utilized little by little for lumber and building material, generally used locally and manufactured in the small water mills which were common in every town. Early census figures for Worcester County, Massachusetts,[4] whose history is typical of most of the region, show that the percentage of cleared land rose steadily until about 1830 and at its maximum included from 55 to 65 per cent of the total land area, exclusive of ponds, swamps, etc.

About 1850, with the opening of the West, the development of the principal railroads, and soon afterward with the drain of the Civil War, land abandonment set in in earnest. For a time the effect upon the area in farms was partly neutralized by the clearing of new land hitherto in forest; but the decline has continued down to the present day so that nearly seven million acres were thus left to revert to nature between 1880 and 1925. From 1850 on, while New England farming and farming populations were rapidly declining, the old fields and pastures were seeding up to new forest, much of it pure stands of white pine. Meanwhile, as the local supplies of original forest disappeared, wood-working industries, originating in the early towns and gradually developing with the improvement of markets and transportation, began to use these second-growth forests, many of which by 1890 had reached merchantable size. From that date to 1925, for wooden boxes and woodenware alone, fifteen billion feet of pine lumber have been cut, over 80 per cent of which originated on old farms abandoned since 1845.[5] At a fair average yield per acre of 10,000 feet, taking good stands with poor, this is equivalent to one and one-half million acres and represents a manufactured value of not less than four hundred million dollars. More than half of this generous sum went to the populations of the towns where the timber grew, an unearned income which in many communities has gone far to keep the remaining farms alive.[6]

Now that the use of old-field timber has been in progress for more than a generation, still a third phase of land use, or, perhaps more properly, disuse, is well advanced, and is represented by an immense and increasing extent of cut-over area, much of it covered with comparatively worthless stands of inferior hardwoods or underbrush, and much of it a frequent prey to forest fire. At the same time, especially in southern New England where hardwood forests predominated, great areas that had not been cleared for farms but were periodically cut for local wood supplies became more and more degenerate in composition and vigor through the drain of repeated sprouting from the same stumps with less and less renewal by new seedlings. Today in the upland farming districts of New England the amount of area to be classed only as woodland is at least 60 per cent, or a little more than what it

was a hundred years ago. Nature has produced a second crop of timber; but, according to any present or foreseeable use, the third crop is a liability rather than an asset.

Forest History of the Lumbering District

If we now consider the history of forests in the northern or lumbering district, we find a similar but less rapid decline in value and productiveness. In the earlier days of lumbering, especially in the state of Maine, only the larger, better trees were cut, at first white pine and later, as pine became exhausted about 1870, spruce, which was for a long time the principal building material in New England. Later, with the development of modern sawmills and more efficient logging methods, the forests were cut more heavily. Always there has been a steady reduction in the better species of timber trees; and, though the earlier partial cuttings had a tendency to allow replacements in the forest and thus keep it moderately productive, the lumber areas of the north as a whole showed a gradual increase in the relatively inferior hardwood element as compared with spruce and pine. Here also, as in the farming district, cut-over lands were apt to burn destructively and over large areas and thus occasion a serious deterioration in the quality and quantity of forest production.

Depletion of the Forests

Thus in two centuries the people of New England have used up all but a scant two million acres of an original forest covering thirty-nine of the forty million acres included in the six states. Not less than fifteen million of these acres became farm and pasture, of which at least ten million have been abandoned to revert to forest and thus accidentally to produce a supplementary crop of timber, the best of which has now also been cut down. There are still about twenty-seven million acres in woodland, but of this more than half is covered with comparatively valueless trees or undesirable species. For a region two fifths of which is probably unfit for anything but the growing of timber this situation is economically discouraging. But even less favorable as related to the problem of restoring forests for the future are the less obvious indirect effects produced by this period of destructive or neglectful use upon the physical and biological factors of the forest—for example, the condition and distribution of tree species, the prevalence of pests, the fertility of soils, the fluctuations of wild life.

Effects of Forest Weeds

Today perhaps the greatest natural obstacle of all to successful forestry, at least in central New England, is the extent to which forest weeds, both trees and underbrush, have multiplied as compared with

the species of greatest use and value. As long as most of the land was occupied either with tillage or pasture or by the still uncut areas of original forest in which only the long-lived and better timber trees survived, the weed element remained in abeyance. Thus, during the earlier abandonment of farm lands it was still white pine as the species most adapted to prompt reseeding that took possession of the fields and pastures; but, as time went on and more land was abandoned, the light-seeded, fast-growing species—gray birch, pin cherry, poplar, red maple, alder, to say nothing of many kinds of shrubs—were able to rival the pine and outstrip the larger, heavier-seeded hardwoods in spreading over vacant lands. Still further impetus was added to the spread and development of forest weeds after the pine wood lots began to be cut and left, as they almost invariably were, to come up to a thicket of hardwoods. In such thickets the stock of valuable seedlings that originated under the pine stand is gradually suppressed by the faster-growing shrubs and forest weeds. Less rapidly but nevertheless steadily a similar process has been going on in the wilder regions where lumbering has been the only treatment of land. Fires also, which only provide further areas more adapted to poor than to good species of trees, have aggravated the process. The increase in forest weeds as compared with desirable timber trees during the last two hundred years is beyond estimate. In central New England it is probable that there are at least five hundred acres of forest weeds to one of good timber, actual or prospective.

Deterioration of Soil

That our present woodland is so much of it intrinsically of little use is not the end of the trouble. Since the present associations of species occur almost wholly as results of farm abandonment, lumbering, or fire, they are often physiologically unsuited to the sites they occupy and therefore, in the absence of fire, tend gradually to revert to some other mixtures more adapted to the local factors of soil and climate. Conversely, these temporary or transitional forests may often have an injurious effect upon the current fertility of the soil, so that, even where a given kind of timber may be commercially valuable, it does not follow that it may be safely reckoned upon as a permanent forest crop for the land. A case in point is the large area of old-field pine already referred to, which has proved so valuable a raw material for local woodworking industries during the last generation. These stands, originating on medium to better soils often improved over their primitive condition by a century of farming or grazing, exhibited in early life a rapid growth. Experience and research at the Harvard Forest[7] have shown that such pine stands gradually arrest most of the organic decomposition that in a healthy forest tends to maintain soil fertility and at the same time exhaust

the original top soil, so that at fifty to sixty years of age their growth suddenly falls off. On the other hand, the replacement of such pine stands with certain associations of deciduous trees has proved beneficial by restoring under the more active influence of temperature, moisture, and light, the metabolism of organic materials that is indispensable to the productiveness of a forest soil. It is axiomatic that cultivation and fertilization as applied to agriculture will always be impracticable in forestry. The only way in which these processes can be kept up in forests is by the use of such species as will maintain the necessary decomposition of forest débris and favor the biological influences—earthworms, fungi, etc.—that supplement the action of physical factors. Not all natural forests accomplish this, since in all cases the general regional climate is the deciding factor; but many associations are beneficial, especially if properly managed. To build up a favorable forest soil may be the work of years. With our present inferior second-growth forests, soils have widely deteriorated: first, by the transition to unfavorable mixtures of species or stands of inadequate density; and second, and often repeatedly, because forest fires have consumed the organic element in the soil.

Insect Pests and Diseases

This general transition from mixed forests of older woods into smaller stands of short-lived or enfeebled trees has brought with it increasingly favorable conditions for insect pests and disease. In the original forests the absence of large areas of any one type of vegetation of uniform age or condition prevented the undue development of pests peculiar to any given species. In the woods of today we find immense tracts of relatively unhealthy forest running strongly to one type of mixture or often to pure stands and, in consequence of their life history, less vigorous than the forests they have replaced. How this has affected insects is indicated by the history of the white pine weevil, a native insect and now one of the most destructive pests of white pine plantations. Relatively harmless in the original forests, where pine did not often grow in continuous bodies and where the percentage of younger stands at any one time was low, this insect found in the period of farm abandonment and the widespread reversion of these lands to pure pine a favorable environment on an immense scale. Today the white pine weevil is so abundant and widespread as to destroy a large part of the value of most pine stands within its range.

Relation of Wild Life to Forest Environment

Among biologists the essential control of wild life by the character of the environment is admitted, if not yet understood in detail. A significant example may be found in the way in which the known

fluctuations of the partridge and the woodcock in central New England have followed the progress of land abandonment, reversion to pine wood, and subsequently to various mixtures of hardwood. Neither of these species was naturally abundant in the heavy forests of early New England; but from 1870 to 1900, during the period of most rapid reversion of old fields to forest, both species reached the greatest abundance recorded by sportsmen. That the partridge has since steadily declined in abundance and the woodcock, at least recently and locally, increased may well be accounted for by the changes that have taken place in the character of the cover and attendant food supply.[8]

The pine wood developed on old fields and pastures, together with more or less hawthorn, running blackberry, viburnum, blueberry, apple trees, and birches. The process of change from shrubby field to forest was gradual, and during the first twenty to thirty years the combination of vegetation was ideal for the partridge—increasing shelter, varied food plants, and open dusting places. From then on the pine rapidly closed up; and most of the food plants, even the old apple trees, were killed out. Since the bulk of the pine woodlands reached this condition twenty to thirty years ago, the favorable cover was reduced to the margins where the pine gave way to brushy openings or birch thickets more characteristic of recently abandoned fields. Thus there was going on a progressive reduction in good cover even before the logging activities of the last generation.

But if the maturing and removal of the old-field pine has deprived the partridge of more and more of his best habitat, the process has, in many cases, accomplished the opposite for the woodcock. This came about through the soil changes referred to above. In the soil under a pine wood there are no earthworms. With the change to certain species of hardwood, if the situation is not too wet or too dry, the original bed of leaf litter disappears in from fifteen to twenty years, the current fall of hardwood leaves decays almost annually, and the resulting fine humus merges with the mineral soil, sometimes to a depth of ten inches or more. There results a rich brown loam in which earthworms are characteristically abundant. On many such areas, once the new forest has begun to close up, breeding woodcock have appeared in numbers. This transformation is not universal but is apparently confined to certain combinations of sites and tree species. In sum total, however, the change has taken place in favorable spots over wide areas. Thus, there would seem to be reason for the recent abundance of woodcock in northeastern covers.

The Future of New England Forests

Looking to the future it is plain that, even though rapid changes in utilization and the recent decline in the demand for native timber

make it difficult to predict what kinds of forest should be the objective of forestry in the several regions, nevertheless, it is safe to expect that from one fourth to one third of New England's area must be used, if at all, as forest. If it is to be used as forest, its permanence and productiveness, whether for wood, safeguarding of stream flow, protection of wild life, or recreation, will have to be secured by a proper understanding and control of the biological and physical factors that have hitherto been so seriously upset. Much of the knowledge necessary for this kind of management is still lacking. The required principles, however, are evident. In many ways the conditions obtaining in the original virgin forests were favorable, but reproducing the complexities of their life history will not make a productive forest. Their very stability involved also an undue slowness of growth, a high percentage of defect, and, as compared with ideal conditions, relatively inactive soils. On the other hand, although much of our second-growth timber has had periods of excellent commercial value and has exhibited very rapid growth—as in the case of the white pine wood lot—such types do not offer a safe model for sound forestry. Being in nearly every case the product of human interference with natural conditions, these types are almost invariably unstable, both as to composition of species and soil conditions. The silviculture of the future will copy the virgin forest by selecting the most valuable, fast-growing, or hardy species so mingled as to secure the greatest possible mutual protection from insects and disease, and the best influence upon soil metabolism and upon the quality of wood. It will follow to some extent also the more uniform density and concentrated production shown by the best of the second-growth forests, in which, for brief periods at least and for certain types, timely exposures of the soil and the predominance of certain beneficial species have produced high yields of wood as well as active fertility. Whatever may prove to be the economic or social objectives of New England forest policy, it will be necessary in the long run to understand and control an essential equilibrium of biological factors, on the one hand to avoid the wasteful complications of the natural process and, on the other, to restore and maintain the resources in good timber and productive soil that human occupation has by now so greatly reduced.

NOTES

[1] For additional bibliographical data see the notes to Dean H. S. Graves's paper entitled *Forest Economics and Policy in New England*, in the present volume, pp. 224–236, below. For a general description of New England forests see R. C. Hawley and A. F. Hawes, *Forestry in New England: A Handbook of Eastern Forest Management*, New York, 1912; the same, *Manual of Forestry for the Northeastern United States, Being Vol. 1 of "Forestry in New England," Revised*, New York, 1918, 1925.—EDIT.

[2] *Life History of the Climax Forest on the Pisgah Tract, Winchester, New Hampshire*, Harvard Forest Study (unpublished manuscript).

[3] A. C. Cline and C. R. Lockard, *Mixed White Pine and Hardwood*, Petersham, Mass., 1925 (*Harvard Forest Bull. No. 8*). [See also R. M. Harper, *Changes in the Forest Area of New England in Three Centuries*, in *Journ. of Forestry*, Vol. 16, 1918, pp. 442–451.—EDIT.]

[4] Early decadal census of Worcester County, Massachusetts (original in possession of the American Antiquarian Society, Worcester, Mass.).

[5] *Analysis of the Wooden Box Industry in New England: A Study Made for the New Hampshire Lumbermen's Association by the Harvard Forest, Distributed Among Members of the Industry by the New England Council*, 1926.

[6] R. W. Averill, W. B. Averill, and W. I. Stevens, *A Statistical Forest Survey of Seven Towns in Central Massachusetts*, Petersham, Mass., 1923 (*Harvard Forest Bull. No. 6*).

[7] B. G. Griffith, E. W. Hartwell, and T. E. Shaw, *The Evolution of Soils as Affected by the Old Field White Pine-Mixed Hardwood Succession in Central New England*, Petersham, Mass., 1930 (*Harvard Forest Bull. No. 15*).

[8] R. T. Fisher, *Our Wild Life and the Changing Forest*, in *The Sportsman*, Vol. 5, March, 1929, p. 65.

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